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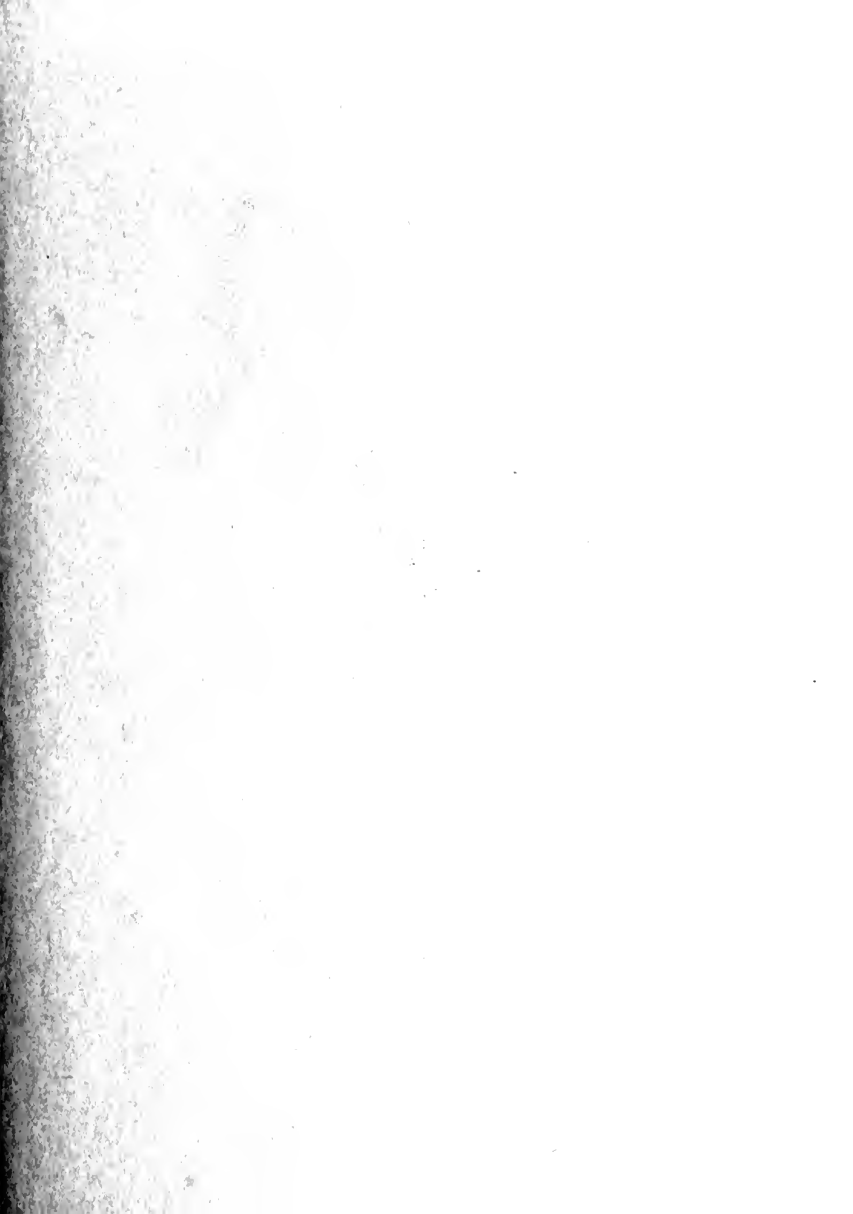
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THE RESOURCES AGENCY OF CALIFORNIA
Department of Water Resources

BULLETIN No. 113

VEGETATIVE
WATER USE STUDIES
1954-1960

Interim Report

AUGUST 1963

HUGO FISHER

Administrator

The Resources Agency of California

EDMUND G. BROWN

Governor

State of California

WILLIAM E. WARNE

Director

Department of Water Resources

State of California
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ERRATA

Bulletin No. 113, 'Vegetative Water Use Studies, 1954 - 1960'

Plate 1, Agroclimatic Stations No. 4, 57, 61, 75, 93, 101:

For "Inactive - 1960" read "Active - 1960"

Plate 2, For "Evapotransperometer" read "Evapotranspirometer"

Page 58, line 10, For "Figures E and F" read "Figures A and B"

Page 66, line 21, For "Figures A and B" read "Figures E and F"

TABLE OF CONTENTS

	<u>Page</u>
LETTER OF TRANSMITTAL	vii
ORGANIZATION, DEPARTMENT OF WATER RESOURCES	viii
ORGANIZATION, CALIFORNIA WATER COMMISSION	ix
ACKNOWLEDGMENT	x
 CHAPTER I. INTRODUCTION	 1
Need for Vegetative Water Use Studies	1
Authorization	2
Objective	3
Scope of Present Program and Report	4
 CHAPTER II. AGROCLIMATIC MONITORING PROGRAM	 7
Instrumentation at Agroclimatic Stations	8
Atmometers	8
Evaporation Pans	9
Agroclimatic Data Analysis	9
 CHAPTER III. EVAPOTRANSPIRATION MEASUREMENT	 21
Measurement of Data Related to Evapotranspiration	22
Criteria for Selection of Plots	24
Evapotranspiration Measurement Technique and Discussion of Development and Current Methods	25
Field Plot Sampling Neutron Scattering Technique	29
Pittville Neutron Probe Moisture Depletion Measurements	31
Arvin Neutron Probe Moisture Depletion Measurements	34

TABLE OF CONTENTS (continued)

	<u>Page</u>
Evapotranspirometer Measurements	36
Alturas-Dorris Ranch Evapotranspirometer Measurments	37
Coleville Evapotranspirometer Measurements	39
Davis Evapotranspirometer Measurments	40
Evapotranspiration Data Summary	40
 CHAPTER IV. CORRELATION OF EVAPOTRANSPIRATION DATA WITH AGROCLIMATIC DATA.	 51
Evapotranspiration and Climatic Data	52
Evapotranspiration and Plant Conditions	53
Evapotranspiration and Soil Moisture	54
Other Factors Affecting Evapotranspiration	55
Determination of Coefficients	55
Grass and Pasture Coefficients	57
Alfalfa Coefficients	58
Cotton Coefficients	63
Application of Coefficients and Evaporation Data to Estimation of Evapotranspiration ,	 67
 CHAPTER V. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS . .	 71
Summary	71
Conclusions	74
Recommendations	75
Appendix A. Supplemental Agroclimatic and Evapo- transpiration Data	 77

TABLE OF CONTENTS (continued)

TABLES

<u>Number</u>		<u>Page</u>
1	Mean Monthly Evaporation From Standard U. S. Weather Bureau Evaporation Pans	12
2	Mean Monthly Evaporation Difference Between Livingston Spherical Black and White Atmometers. .	12
3	Monthly Evaporation From Standard U. S. Weather Bureau Evaporation Pans in Order of Decreasing Magnitude For Irrigated Pasture and Dryland Stations	16
4	Monthly Evaporation Difference Between Livingston Spherical Black and White Atmometers in Order of Decreasing Magnitude For Irrigated Pasture and Dryland Stations	19
5	Summary of Measurements of Evapotranspiration and Related Data	42
6	Pan and Atmometer Coefficients for Pasture and Grass	59
7	Pan and Atmometer Coefficients for Alfalfa	64
8	Pan and Atmometer Coefficients for Cotton	68
9	Comparison of Seasonal Consumptive Use of Alfalfa, Pasture, and Cotton Based on Bulletin No. 2 Growing Season	69

FIGURES

<u>Number</u>		<u>Page</u>
1	Atmometer Assembly	10
2	Typical Agroclimatic Stations	11
3	Platforms Used to Minimize Crop Damage and Soil Compaction	32
4	Access Tube Design	33
5	Evapotranspirometer Designs	41

TABLE OF CONTENTS (continued)

PLATES
(Bound at End of Bulletin)

Number

- 1 General Location of Agroclimatic Stations
- 2 General Location of Evapotranspiration Stations
- 3 Comparison of Evapotranspiration Curves of Different
Crops Grown at the Same Location on the Same Soil
Series
- 4 Variation of Pan and Atmometer Coefficients for
Individual Periods of Measurements
- 5 Comparison of Pan and Atmometer Coefficients for
Cotton, Alfalfa and Grass
- 6 Relationship Between Pan and Atmometer Coefficients
For Alfalfa and Ground Cover

AM. E. WARNE
Director of
Resources

JOE GOLDBERG
Deputy Director

ALD C. PRICE
Director Policy

LY GARDNER
Deputy Director
Administration

ED R. GOLZE
Chief Engineer

EDMUND G. BROWN
GOVERNOR OF
CALIFORNIA

HUGO FISHER
ADMINISTRATOR
RESOURCES AGENCY

ADDRESS REPLY TO
P. O. Box 388
Sacramento 2, Calif.



THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

1120 N. STREET, SACRAMENTO

June 20, 1963

Honorable Edmund G. Brown, Governor
and Members of the Legislature
of the State of California

Gentlemen:

I have the honor to transmit herewith Bulletin No. 113, "Interim Report on Vegetative Water Use Studies, 1954-1960," of the Department of Water Resources, dated May 1963. This report describes techniques and approaches which have evolved, and summarizes data on vegetative consumptive use or evapotranspiration. Interrelationships between these data are set forth, together with evapotranspiration values for some crops in Central and Northern California agricultural areas. This is a continuing study with many conclusions yet to be reached.

Data pertaining to evapotranspiration, irrigation requirements, and agricultural hydrology are basic to most water resource development studies. With the continued growth of the State, necessitating more complex and costly water development facilities, there is increasing need for more accurate water use data. Such data will enable developed surface and ground water resources to be used effectively, and will facilitate design and operation of land drainage systems.

The studies reported herein were initiated in 1954 as part of the Northeastern Counties Investigation. A continuing Vegetative Water Use Studies Program was established, and the studies were broadened, as a result of Senate Bill 434, 1959 Legislative Session. Specific authorization for these studies is set forth in Section 226(e) of the Water Code.

Sincerely yours,

William E. Warner
Director

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

EDMUND G. BROWN, Governor
HUGO FISHER, Administrator, The Resources Agency of California
WILLIAM E. WARNE, Director, Department of Water Resources

ALFRED R. GOLZE, Chief Engineer

Division of Resources Planning

William L. Berry, Division Engineer
Albert J. Dolcini, Chief, Planning Management Branch

Technical studies were conducted and
the bulletin was prepared under the supervision of

John W. Shannon Water Utilization Staff Specialist

Assisted by

Reginald E. Merrill Associate Land and Water Use Analyst

Norman MacGillivray Assistant Land and Water Use Analyst

Field data were collected under
the supervision of

Jack H. Lawrence Senior Land and Water Use Analyst

Assisted by

John Kono Assistant Land and Water Use Analyst

Andrew Lee Junior Land and Water Use Analyst

Arthur deRutte Assistant Land and Water Use Analyst

Patrick Duval Assistant Land and Water Use Analyst

Robert Bowman Assistant Land and Water Use Analyst

Victor Uhlik Assistant Land and Water Use Analyst

Darrell Nichols Assistant Land and Water Use Analyst

Zene Bohrer Assistant Land and Water Use Analyst

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WILLIAM M. CARAH
Executive Secretary

GEORGE B. GLEASON
Principal Engineer

ACKNOWLEDGEMENT

The Department of Water Resources wishes to express appreciation to many organizations and individuals who have assisted the department in the Vegetative Water Use Program. Many private farm operators have provided use of their property and equipment, as well as time. The list is too numerous to completely enumerate; however, the Frick Farms at Arvin, Roland Hutchings at Pittville, and the U. S. Fish and Wildlife Service (formerly Dorris Ranch) at Alturas have been particularly helpful.

A very considerable amount of technical guidance has been given by the Irrigation Department of the University of California at Davis. The University Agricultural Extension has given assistance in the search for plot sites.

The assistance and collaboration provided by the U. S. Forest Service, the Agricultural Research Service and the Soil Conservation Service of the U. S. Department of Agriculture; the California Division of Forestry; and the Agricultural Commissioner's Office, to mention a few, are likewise gratefully acknowledged.

CHAPTER I. INTRODUCTION

This report presents data on vegetative consumptive use of water, or evapotranspiration, together with certain interrelationships with agricultural climatic factors influencing such use. The findings summarized cover the period 1954-1960, and represent a large quantity of individual measurements of evapotranspiration and related agricultural climatic data. The measurements of evapotranspiration represent scores of soil samples, neutron probe readings, and evapotranspirometer measurements of irrigated alfalfa, pasture, plums, cotton, and grass crops. Agricultural climatic or agroclimatic data are likewise summarized from a large number of measurements of evaporation from pans and atmometers. Certain other agroclimatic data, such as measurements of solar radiation and relative humidity, were collected at a few stations. These data have not been analyzed as yet, and will be reported in later publications.

Need for Vegetative Water Use Studies

Historically, irrigated agriculture has been the largest user of our developed water resources. This condition probably will continue indefinitely. The Department of Water Resources, hereinafter referred to as the department, and its predecessor agencies, have made many measurements of water deliveries for agricultural uses with regard to water right adjudication. However, for broad planning purposes the department has relied largely upon

empirical methods for estimating seasonal values of evapotranspiration or consumptive use for various crops. State Water Resources Board Bulletin No. 2, "Water Utilization and Requirements of California, 1955," has been the primary source for such estimates.

As more complex and costly water development facilities are contemplated, more accurate values for irrigation requirements and evapotranspiration will be needed. The location and sizing of reservoirs, distribution systems, and final disposal or drainage systems are dependent upon accurate estimates of at least monthly values of irrigation requirements and evapotranspiration for various kinds of vegetation. Accurate irrigation requirements and evapotranspiration values are also important in planning for the conjunctive operation of ground water reservoirs, the reclamation of salt-affected lands, and in the maintenance of a favorable salt balance within agricultural soils. Moreover, as water costs rise, more accurate knowledge of evapotranspiration rates will become of increasing importance in order to achieve greater efficiencies in irrigation practices.

Authorization

Estimates of evapotranspiration and irrigation requirements have long been a part of water development investigations, as conducted by the department and its predecessor agencies. The present program, designed to provide more accurate data on rates of evapotranspiration, was initiated in July 1954 and broadened in 1959, pursuant to Senate Bill 434, 1959 Legislative Session. Specific authorization for conducting these studies is set forth

in Section 226 (e) of the Water Code, which states that the department may "Conduct investigations of the rate of use of water for various purposes and considering various soil conditions."

Objective

The overall objective of the vegetative water use studies is to investigate and establish a means whereby the department can accurately determine long-term monthly and seasonal irrigation requirements and evapotranspiration for the principal crops grown within the various agricultural zones throughout California. To accomplish this broad objective, the vegetative water use studies are divided into three principal programs; namely, agroclimatic monitoring, evapotranspiration measurement and correlation, and irrigation requirement determination. The first two of these programs are designed to accomplish the following primary objectives: first, to collect agroclimatic data in major agricultural areas to provide a means of dividing the State into agroclimatic zones of potential water use, and for estimating evapotranspiration within those zones; and second, to test, on a statewide basis, certain procedures suggested by fundamental research by the University of California and other agencies, regarding correlation of evapotranspiration with various types of agroclimatic data. The objective of the third program is to correlate measured values of total applied water with evapotranspiration. These data will make possible the calculation of other pertinent water use information, such as irrigation efficiencies and drainage requirements. Very little has been accomplished on the third program to date.

Scope of Present Program and Report

To accomplish the foregoing objectives, it is necessary to measure evapotranspiration for various crops within the major agricultural zones of the State, and to measure various climatic, plant, and soil factors which influence evapotranspiration. To date, accurate measurements of evaporation have been made of only a few crops within certain of the major agricultural service areas of the State, because of financial and personnel limitations. Additional installations will be required to provide complete evaluation of all major agricultural zones and the principal crops grown within California.

In order to maximize the utility of the data provided by the relatively few evapotranspiration measurement stations, a correlative program has been carried on to relate evapotranspiration to evaporation indices. Theoretically, coefficients derived by comparing evapotranspiration to evaporation from pans or atmometers can be used to make reliable estimates of evapotranspiration within any agroclimatic zone where evaporation data are available. Basic research on such relationships is being conducted by the University of California as a part of the vegetative water use program.

The agroclimatic monitoring program, described fully in Chapter II, is designed to collect the basic agroclimatic data necessary to make reliable estimates of evapotranspiration within each agroclimatic zone. Chapter III discusses evapotranspiration measurements and the collection of data relative to plant conditions, soil moisture, and other factors which may affect evapotranspiration rates. The criteria, methods, and instrumentation

used in the measurements are described generally, and the data collected through 1960 are summarized. Since the initiation of this program in 1954, improvements and standardizations within the program have vastly improved the quality of the data collected, such that one hesitates to compare data collected in 1960 with earlier years of records. Consequently, judgment was exercised in summarizing certain of the earlier data.

In Chapter IV, measured evapotranspiration rates described in Chapter III are correlated with pan and atmometer evaporation data which were collected concurrently at the evapotranspiration plots. The pan and atmometer coefficients, so derived, are then applied to the agroclimatic data to estimate evapotranspiration for a few crops throughout much of the northern part of the State. While comparisons are made with the values published in Bulletin No. 2, it is not the intent of this report to imply a question as to the accuracy of previous values used by the department. Instead, this report is intended to indicate some of the problems involved in the collection and analysis of the data and, to the extent of the data collected, to show tentative values that may be used for the determination of water requirements for certain crops.

A great deal of the basic research fundamental to this study was conducted by the University of California at Davis, both prior to and since the initiation of this program. The continuing counsel and guidance provided by various members of the University of California have been of invaluable assistance in the development of these studies.



CHAPTER II. AGROCLIMATIC MONITORING PROGRAM

As stated in Chapter I, the objective of the agroclimatic monitoring program is to collect and analyze climatological data throughout the various agricultural water service areas within the State. The analyses of these data will accomplish two purposes. First, they will enable segregation and delineation of zones or areas with similar evaporation potentials. Secondly, these data will provide a basis for estimating evapotranspiration rates of various crops within those zones. This can be accomplished by utilizing coefficients which relate measured crop evapotranspiration (to be discussed in Chapter III) to agroclimatic data. The program of correlating measured evapotranspiration to various evaporative indices, such as evaporation pans and atmometers, is discussed in Chapter IV.

To date, agroclimatic stations have been established at typical locations within certain of the major inland agricultural areas in the central and northern portions of the State. The data collected and summarized in this report comprise weekly measurements of evaporation from U. S. Weather Bureau Standard Class A pans, and differences of evaporation between Livingston black and white atmometers. Measurement of solar radiation, air temperature, and humidity was made at a few locations. These data, however, are not included in this report, as research regarding their relationships to evapotranspiration and methods of analysis are still in the process of development.

As of 1960, the program included 52 stations, although a total of 112 stations have been operated for various periods of

time. Many of the original stations have been discontinued because of unfavorable site conditions or other causes. The location and status of each station are shown on Plate 1, entitled "General Locations of Agroclimatic Stations, 1954-60." A more detailed description of each of the agroclimatic stations is presented in Table A-1 of Appendix A.

Instrumentation at Agroclimatic Stations

Two types of equipment were utilized to measure evaporation potential; the Livingston spherical atmometer, and the U. S. Weather Bureau Standard Class A evaporation pan. U. S. Forest Service precipitation gages, approximately 8 inches in diameter and 10.5 inches in height, were installed at all agroclimatic stations at the same elevation above ground as prescribed for a standard U. S. Weather Bureau nonrecording rain gage. Following is a description of evaporation equipment in use and methods of installation.

Atmometers

A Livingston spherical atmometer is a specialized instrument used for measurement of evaporation. The atmometer is a hollow porous porcelain sphere 5 centimeters in diameter. In a typical assembly the sphere is mounted on a 1-gallon water supply bottle by means of a small-diameter glass tube. The sphere and connecting tube are filled with distilled water, with the lower end of the tube extending nearly to the bottom of the reservoir bottle. Thus, there is a continuous water system from the reservoir bottle to the outer surface of the porous sphere, where evaporation takes place.

Evaporation is determined by measuring the amount of water required to refill the reservoir bottle to a reference mark. A typical atmometer assembly is shown on Figure 1.

Atmometers are operated as pairs consisting of one white and one black sphere set 15 inches apart and 54 inches above ground surface. Prior to 1958, many installations had only a single pair of atmometers; however, since that time three or more pairs of atmometers have been installed at each of the stations included in the monitoring program.

Evaporation Pans

U. S. Weather Bureau Standard Class A evaporation pans were adopted in the agroclimatic program in 1957 and installed at certain of the stations. The pans were installed in accordance with the procedure prescribed in "Instructions for Climatological Observers," Circular B. Tenth Edition, Revised October 1955, U. S. Department of Commerce.

All stations included in the Agroclimatic Monitoring Program are periodically inspected to ascertain that equipment is correctly installed and properly exposed. Complete records for all stations are available in the files of the department. Typical agroclimatic station installations are shown in Figure 2.

Agroclimatic Data Analysis

Summaries of the agroclimatic data collected during the period from July 1954 through December 1960 are shown in Tables 1 and 2. Table 1 shows the means of monthly evaporation from standard

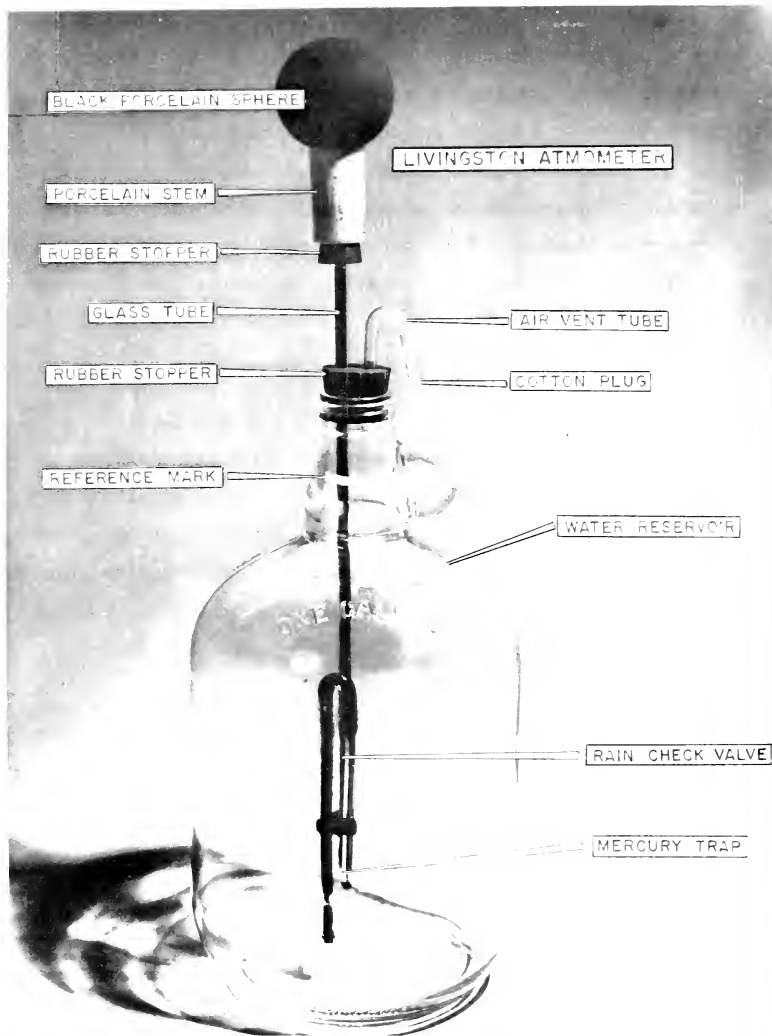


Figure 1, ATMOMETER ASSEMBLY



Station Located
in Irrigated Pasture
near Lodi



Station Located
in Dryland
Environment
near Redding



Station Located
in Non-irrigated
Alfalfa near
Adin, Modoc County

FIGURE 2. TYPICAL AGROCLIMATIC STATIONS

TABLE 1
MEAN MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Environment and area	Number of : Station : : Years : Record	Years	MONTHS												May : Sept. : Total
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<u>Pasture</u>															
Klamath-Trinity Mt. Valleys	2	1959-60					6.95	8.76	11.06	8.44	6.18				41.39
Sacramento River Basin Mountain Valleys	9	1957-60	-	1.48	3.25	5.10	6.16	7.69	8.96	8.78	6.16	3.86	1.66	0.66	37.75
Sacramento River Basin Foothills	7	1957-60	1.52	2.29	3.56	5.19	6.30	9.15	10.66	9.27	6.44	5.00	2.20	1.52	41.82
Sacramento River Basin Valley Floor	12	1958-60	1.65	2.49	4.04	5.48	7.26	10.28	10.73	9.18	6.87	5.34	2.58	1.74	44.32
San Joaquin River Basin Valley Floor	11	1959-60	1.67	2.18	4.19	6.08	8.84	10.60	10.55	9.08	6.76	5.14	1.92	1.30	45.83
Tulare Lake Basin Valley Floor	6	1958-60	1.79	2.18	4.15	5.76	8.77	9.74	9.36	8.11	6.00	4.24	1.98	1.16	41.98
Lassen-Alpine Mountain Valleys	6	1957-60	--	--	--	--	6.30	8.91	10.97	9.81	6.85	4.35	--	--	42.84
<u>Dryland</u>															
Sacramento River Basin Mountain Valleys	8	1958-60	--	1.20	2.99	5.98	5.95	10.02	12.03	11.06	7.41	4.60	2.09	--	46.47
Sacramento River Basin Foothills	7	1958-60	1.42	2.75	4.60	6.52	8.69	13.36	15.04	12.46	10.27	7.42	3.09	2.94	59.82
Sacramento River Basin Valley Floor	9	1958-60	1.26	2.48	4.88	6.52	8.95	13.25	14.03	11.87	9.45	7.24	3.19	1.90	57.55

TABLE 2
MEAN MONTHLY EVAPORATION DIFFERENCE BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Environment and area	Number : of : Stations	Years : of : Record	MONTHS												May : Sept. : total
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
<u>Pasture</u>															
Sacramento River Basin Mountain Valleys	13	1955-60					463	550	600	545	417				2575
Sacramento River Basin Foothills	10	1958-60		292	453	494	572	619	562	466	375				2713
Sacramento River Basin Valley Floor	13	1958-60		324	424	491	568	614	549	443	366				2695
San Joaquin River Basin Valley Floor	11	1959-60		374	460	529	569	580	543	449	366				2670
Tulare Lake Basin Valley Floor	6	1958-60			440	520	572	580	551	444		373	231		2667
Lassen-Alpine Mountain Valleys	8	1955-60					460	545	572	550	454				2581
<u>Alfalfa</u>															
Klamath-Trinity Mountain Valleys	3	1955					550	558	539						
Sacramento River Basin Mountain Valleys	11	1955-59				486	537	566	568						2601
Sacramento River Basin Valley Floor	17	1955, 58-60		384	445	539	580	618	556	444	389				2765
San Joaquin River Basin Valley Floor	13	1958-60		284	470	548	571	582	548	454	379				2703
Tulare Lake Basin Valley Floor	9	1958-60		402	462	538	589	617	563	447	409				2754
<u>Dryland</u>															
Klamath-Trinity Mountain Valleys	15	1954-60					446	521	584	546	413				2510
Sacramento River Basin Mountain Valleys	26	1954-60					470	536	569	540	408	310			2523
Sacramento River Basin Foothills	4	1959-60		323	395	468	576	658	593	458	388				2753
Sacramento River Basin Valley Floor	17	1954-60		366	426	511	568	655	573	465	366				2792
Lassen-Alpine Mountain Valleys	7	1955-56 & 1958-59					520	582	535						
<u>Miscellaneous</u>															
Sacramento River Basin Valley Floor	9	1954-55, 57, & 60				403	511	581	628	567	442	351			2789

U. S. Weather Bureau pans. Table 2 indicates the mean monthly difference of evaporation between Livingston spherical black and white atmometers.

At the initiation of the program in 1954, little was known of the effects of the immediate ground cover environment on evaporation from atmometers and pans. Furthermore, little consideration had ever been given to the effects on evaporation rates of surrounding land areas or cleanliness of pans at stations having apparently similar immediate environmental conditions. In analyzing the data it became apparent that certain of these factors are extremely important.

In the initial tabulations of evaporation data, great differences were noted between adjacent stations having dissimilar environmental conditions. A tabulation on the basis of station environment shows this to be especially true for evaporation pans, as may be noted in Table 1. For example, Table 1 indicates that the May through September total of the mean monthly evaporation from pans located on dry-farmed rangelands was more than 25 percent greater than evaporation from pans situated on irrigated pasture. This difference became increasingly greater during the summer months. The higher and increasingly greater evaporation on dry-farmed rangelands resulted from the greater availability of energy in surrounding dryland areas, and the increase of advective heating that results as the drylands exhaust moisture carried over from wintertime precipitation during the summer.

An interesting fact determined from studies at the Bakersfield station was that cleanliness, or presence of algae growth, had little effect upon evaporation rates from evaporation pans. During an 18-month period starting in January 1959, three pans were maintained in the same environment and were treated in an identical manner, except that algae was permitted to grow in one pan while the other two were cleaned frequently. The difference of evaporation was small, with only 3 percent greater evaporation in the pan where algae was allowed to grow.

In an evaporation investigation carried on by A. A. Young in Southern California during the period from 1935 to 1939, inclusive, a study was conducted to determine the effect of pan color upon evaporation. He found differences varying from approximately 17 percent less to 7 percent more than from a standard U. S. Weather Bureau pan. It is of interest to note that evaporation from a dark green colored pan was 2.5 percent greater than that from the standard U. S. Weather Bureau pan. The presence and growth of algae appear to give similar results.

The difference in evaporation between black and white atmometers, as shown in Table 2, appears to be affected less by environmental conditions than are pans. This indicates a difference in response between pans and atmometers to various climatic conditions. This will be discussed further in Chapter IV.

Monthly evaporation data from pans and atmometers for each year and for each station are set forth in Tables A-2 and A-3, respectively, of Appendix A. The data are segregated by area and by environment.

The area designations set forth in this report are arbitrary and, in general, principally geographical subdivisions. When additional years of data become available, these area breakdowns must be reconsidered. Analysis of the records of individual stations to date indicates as much variability in evaporation between adjacent stations, within any one area, as between areas. This variability is shown in Tables 3 and 4, in which all of the stations located on irrigated pasture in 1959 and 1960 were arranged in order of decreasing evaporation rate by month. The same was done for the 1959 and 1960 dryland stations. On the basis of these data, it is concluded that no definite segregation of the stations into areas of uniform evaporation is possible.

A general pattern has been discerned with certain of the stations tending to be high and others low. There are indications that, for stations having similar environments immediately surrounding the site, adjacent dryland areas exert climatic influences and affect evaporation rates at the station site.

This factor is being given further consideration in relation to the agroclimatic stations currently in operation. Efforts are being made to standardize conditions where pan and atmometer data are collected. Insofar as possible, large, well-irrigated pastures providing nearly 100 percent ground cover are being selected as sites for agroclimatic stations. As data are obtained under similar environmental conditions, more conclusive comparisons may be made. It may be found that there are small differences in monthly evaporative rates between different agricultural areas of the State, and that the length of growing season is the most important factor affecting seasonal evapotranspiration in inland areas.

MONTHLY EVAPORATION FROM STANDARD U. S. WEATHER BUREAU
EVAPORATION PANS IN ORDER OF DECREASING MAGNITUDE FOR IRRIGATED PASTURE AND DRYLAND STATIONS
(In inches)

-16-

TABLE 3 (continued)

MONTHLY EVAPORATION FROM STANDARD U. S. WEATHER BUREAU
EVAPORATION PANS IN ORDER OF DECREASING MAGNITUDE FOR IRRIGATED PASTURE AND DRYLAND STATIONS
(In inches)

Environment and Pasture	Months											
	July	August	September	October	November	December						
Irrigated Pasture												
1959												
Merced SSE	13.08	Cedarville 2E	11.35	Fall River Mills	8.99	Lincoln Vineyard	6.06	Lincoln Vineyard	3.50	Lincoln Vineyard	2.41	
Montague 3NE	12.50	Merced SSE	10.63	4NW		Gold Hill Doty		Gold Hill Doty		Gold Hill Doty		
Standish 4NW	11.96	Fall River Mills	10.07	Red Bluff Cone	8.32	Flat	5.98	Flat	3.35	Flat	2.24	
Lincoln Vineyard	11.80	4NW		Ranch		Red Bluff Cone		Red Bluff Cone		Red Bluff Cone		
Cedarville 2E	11.56	Lincoln Vineyard	9.39	Merced SSE	7.98	Ranch	5.54	Ranch	3.34	Ranch	2.23	
Gold Hill Doty	11.32	Standish 4NW	9.37	Cedarville 2E	7.31	Merced SSE	5.53	Anderson 4E	2.76	El Solvo Ranch	2.10	
Red Bluff Cone		Penn Valley	9.38	El Solvo Ranch	7.17	El Solvo Ranch	5.47	Arvin Frick	2.69	Merced SSE	1.94	
Penn Valley		El Solvo Ranch	9.01	Lincoln Vineyard	6.74	Cedarville 2E	5.00	Merced SSE	2.68	Thornion 2S	1.69	
Flat		Gold Hill Doty		Anderson 4E	6.62	Lodi 3SW	4.98	Cedarville 2E	2.58	Arvin Frick	1.68	
Ranch		Flat		Penn Valley	6.43	Stockton 9S	4.82	El Solvo Ranch	2.53	Penn Valley	1.60	
Penn Valley	10.81	Flat	8.91	Lodi 3SW	6.41	Anderson 4E	4.64	Stockton 9S	2.43	Anderson 4E	1.58	
Stockton 9S	10.79	Red Bluff Cone		Gold Hill Doty	6.37	Penn Valley	4.49	Fall River Mills		Stockton 9S	1.55	
El Solvo Ranch	10.70	Ranch	8.72	Stockton 9S		Arvin Frick	4.49	4NW		Stockton 9S	1.55	
Lookout Hunt	10.66	Ranch	8.70	Gold Hill Doty	6.37	Kingsburg 5S #2	4.31	Lodi 3SW	2.40	Kingsburg 5S #2	1.38	
Arvin Frick	10.07	Stockton 9S	8.67	Flat	6.37	Lookout Hunt	4.10	Lookout Hunt	2.17			
Lodi 3SW	9.95	Alturas-Dorris		Montague 3NE	6.30	Lookout Hunt		Kingsburg 5S #2	2.16			
Alturas-Dorris		Ranch		Lookout Hunt	5.93	4NW		Penn Valley	1.93			
Ranch		Montague 3NE	8.65	Standish 4NW	5.91	Alturas-Dorris		Alturas-Dorris				
Anderson 4E	9.54	Lodi 3SW	8.56	Kingsburg 5S #2	5.74	Ranch	3.59	Ranch	1.72			
Kingsburg 5S #2	9.26	Anderson 4E	7.72	Alturas-Dorris								
		Kingsburg 5S #2	7.57	Ranch	5.51							
1960												
Lincoln Vineyard	12.97	Lincoln Vineyard	12.16	Coming 3NE	9.02	Coming 3NE	7.55	Coming 3NE	3.90	Coming 3NE	1.93	
Coming 3NE	12.73	Coming 3NE	11.41	Merced SSE	8.05	Newman 1SE	6.24	Lincoln Vineyard	2.66	Red Bluff Cone		
Merced SSE	12.12	Merced SSE	10.65	Cedarville 2E	7.76	Lincoln Vineyard	6.12	Yuba City 9W	2.45	Bench	1.81	
Cedarville 2E	12.01	Cedarville 2E	10.33	Standish 4NW	7.21	Red Bluff Cone		Palermo 3SW	2.39	Lincoln Vineyard	1.75	
Red Bluff Cone		Berenda 2N	9.49	Lincoln Vineyard	7.21	Ranch		Palermo 3SW	2.15	Yuba City 9W	1.59	
Berenda 2N	11.37	Palermo 3SW	9.43	Loma Rica	7.06	Stockton 9S	5.70	Thornion 2S	2.07	Palermo 3SW	1.55	
Palermo 3SW	10.74	Glenburn 4NR	9.20	Red Bluff Cone		Stockton 9S	5.66	Gold Hill Doty		Anderson 4E	1.32	
Gold Hill Doty		Lookout Hunt	9.15	Ranch	7.05	Palermo 3SW	5.60	Flat	2.05	Loma Rica	1.17	
Flat	10.74	Penn Valley	8.98	Gold Hill Doty		Gold Hill Doty	5.27	Red Bluff Cone		Penn Valley	1.12	
Stockton 9S	10.42	Gold Hill Doty		Flat	6.63	Flat	5.16	Bench	2.00	El Solvo Ranch	1.09	
Glenburn 4NR	10.40	Flat	8.91	Palermo 3SW	6.62	Merced SSE		Newman 1SE	1.98	Arvin Frick	1.08	
Palermo 3SW	10.31	Standish 4NW	8.89	Newman 1SE	6.60	El Solvo Ranch	4.94	Penn Valley	1.97	Gold Hill Doty		
Standish 4NW	10.00	Stockton 9S	8.84	Berenda 2E	6.43	Loma Rica	4.94	Arvin Frick	1.89	Flat		
Penn Valley	9.78	Newman 1SE	8.77	El Solvo Ranch	6.43	Cedarville 2E	4.82	Loma Rica	1.81	Stockton 9S	1.07	
Lookout Hunt	9.67	Anderson 4E	8.70	Kingsburg 5S #2	6.20	Penn Valley	4.51	El Solvo Ranch	1.79	Merced SSE	1.06	
Merced SSE	9.58	El Solvo Ranch	8.55	Stockton 9S	6.18	Berenda 2N	4.46	Elk Grove 4NW	1.77	Newman 1SE	0.96	
Anderson 4E	9.58	Kingsburg 5S #2	8.36	Anderson 4E	6.15	Elk Grove 4NW	4.39	Glenburn 4NR	1.74	Thornion 2S	0.95	
Thornion 2S	9.50	Red Bluff Cone		Arvin Frick	6.13	Thornion 2S	4.38	Merced SSE	1.69	Cedarville 2E	0.86	
Arvin Frick	9.39	Ranch	8.36	Montague 3NE	6.07	Kernan 2ESE	4.28	Merced SSE	1.65	Kingsburg 5S #2	0.80	
Kingsburg 5S #2	9.37	Montague 3NE	8.33	Kernan 2ESE	6.02	Arvin Frick	4.08	Kernan 2ESE	1.63	Kernan 2ESE	0.80	
Elk Grove 4NW	9.35	Alturas-Dorris		Lookout Hunt	6.00	Kingsburg 5S #2	4.04	Kingsburg 5S #2	1.62	Elk Grove 4NW	0.79	
Newman 1SE	9.25	Alturas-Dorris		Lookout Hunt	5.99	Glenburn 4NR	3.97	Cedarville 2E	1.60	Berenda 2N	0.74	
El Solvo Ranch	9.15	Yuba City 9W	8.31	Penn Valley	5.99	Anderson 4E	3.91	Berenda 2N	1.43	Lookout Hunt	0.74	
El Solvo Ranch	9.13	Yuba City 9W	8.09	Thornion 2S	5.91	Alturas-Dorris	3.71	Alturas-Dorris	1.13	Ranch	0.65	
Yuba City 9S	8.81	Arvin Frick	7.96	Yuba City 9W	5.86	Ranch		Lookout Hunt	0.82	Glenburn 4NR	0.56	
Kernan 2ESE	8.61	Thornion 2S	7.96	Alturas-Dorris								
Alturas-Dorris		Elk Grove 4NW		Glenburn 4NR	5.86	Lookout Hunt	3.71	Lookout Hunt				
Ranch		Kernan 2ESE	7.43	Elk Grove 4NW	5.86							



CHAPTER III. EVAPOTRANSPIRATION MEASUREMENT

The objective of the evapotranspiration measurement and correlation program is to provide a more accurate basis for predicting evapotranspiration for the major crops in the various agricultural areas of the State. This is to be accomplished through measurements of evapotranspiration of various crops at several inland locations having different climatic conditions, and correlating with the evaporative demand, as measured by evaporation pans and atmometers. This chapter discusses the techniques and procedures utilized in the measurement of evapotranspiration, and changes that have occurred during the development of the study. In Chapter IV the correlation of the evapotranspiration with pan and atmometer evaporation data will be discussed and analyzed.

The principal evapotranspiration stations are located near Bakersfield in the southern San Joaquin Valley and near Alturas and Fall River Mills in mountain valleys of the Sacramento River Basin. Plate 2, entitled "General Location of Evapotranspiration Stations, 1955-1960," shows the location, type, and status of each station. More detailed information is given in Tables A-4 and A-5 of Appendix A. Measurements were made primarily on alfalfa and grass, which are grown universally throughout the State. As plant and soil moisture conditions affect evapotranspiration rates, evaluation of these factors is also an essential part of evapotranspiration measurement.

Measurement of Data Related to Evapotranspiration

Correlative pan and atmometer evaporation measurements were made at agroclimatic stations established near the evapotranspiration measuring stations. These stations are listed in Table A of Appendix A. Detailed information regarding the agroclimatic stations, and pan and atmometer data, are given in Tables A-1, A-2, and A-3 of that appendix.

At Arvin (in Kern County) the pan and atmometer data were initially collected at stations (Arvin Jewett #1 and #2) located in an irrigated alfalfa field near the evapotranspiration station, or soil moisture depletion plots. In June 1959, a new station (Arvin-Frick) was established in an irrigated grass environment. All of the soil moisture depletion plots were within 1 mile of this station.

Only atmometer data were collected at the Pittville AA plot site (in eastern Shasta County) during 1959. This agroclimatic station is identified as Pittville 1 S. Pan data were collected within an irrigated pasture site, designated as Fall River Mills 4 Nw, during 1959, and until June 1960, but due to unfavorable operational procedures at this site in 1959, the pan data were not used in this report.

In June 1960, an agroclimatic station was established at a location within an irrigated pasture 8 miles west of the Pittville AA plot. This station is identified as Glenburn DWR. Comparison of atmometer evaporation measurements at the Pittville 1 S and the Glenburn DWR stations showed that the difference in evaporation between the black and white atmometers is very close for these two locations.

At the Arvin and Glenburn sites, three sets of new atmometers were installed at the beginning of each season, and each month one pair was replaced with a new pair. At Arvin, three pans were operated, and the evaporation, which was nearly the same, was averaged.

Data on percent of ground cover were collected to determine effects of varying cover on evapotranspiration rates. The term "percent ground cover," as used in this report, refers to the percentage of ground surface covered by a canopy of living foliage as viewed looking downward from directly above the crop. During the first years, 1955-1957, few records were kept of percent ground cover. However, from 1958 through 1960 it was standard procedure to measure crop height, estimate percent ground cover, and record both.

When most of the moisture which plants can readily extract from within the root zone has been used, crop growth is slowed and evapotranspiration rates may also be correspondingly affected. To estimate available soil moisture at the test plots, samples were taken and laboratory measurements of the moisture content of the soil were made, utilizing the pressure plate membrane technique with pressures varying from 0.1 to 15 atmospheres. Tensiometers, instruments which can be used to measure availability of soil moisture for crop utilization, were installed at some plots. Calculations of available soil moisture in the root zone were based on the difference between moisture profiles determined from field measurements and moisture profiles representing the moisture level below which crops cannot readily extract moisture.

Criteria for Selection of Plots

In the selection of plots for the measurement of evapotranspiration, certain physical conditions are recognized as essential to collecting valid data. Experience over the years has emphasized the importance of certain necessary conditions. Unfortunately, the most ideal plot conditions are difficult to find, and considerable time and effort have been expended over the years selecting the most favorable sites. However, this is not to imply that evapotranspiration rates would necessarily be different under different conditions. The following criteria indicate the conditions under which good measurements of evapotranspiration representative of field conditions can be obtained. After good measurements have been obtained under these conditions, the studies should be broadened to include some of the adverse soil and other conditions which might affect evapotranspiration.

1. Measurement sites should be located 200 feet inside the edge of the irrigated field to avoid accentuated border effects.
2. Generally, the land should be of smooth topography.
3. Since the sites are located on private lands, it is necessary to have freedom of access and cooperation of the landowner or manager.
4. The soil should be deep, well drained, productive, and unaffected by salinity. The soil preferably should also be medium textured, as very fine or very coarse textures have unfavorable soil-moisture relationships. The soil profile should not be stratified to such an extent as to impede moisture flow or create sampling problems.

5. The irrigated field should be located in typical irrigated areas, not on the fringe of irrigated areas.

6. There should be an adequate supply of irrigation water. It is highly desirable that there be possibilities for controlling and measuring the amount of water applied to the test plot.

7. Except for measurements which are made by evapotranspirometers, no water table should exist within or near the root zone of the crop.

Evapotranspiration Measurement Techniques and Discussion of Development and Current Methods

The tools and techniques used in this study to measure evapotranspiration fall into two general categories. One is field plot sampling, and the other is evapotranspirometer measurements.

Field Plot Sampling - Gravimetric Method

Periodic measurement of soil moisture provides a means of determining total change of water content within a selected portion of the soil profile. Evapotranspiration may be determined from data on soil moisture change and precipitation. Soil moisture must be sampled or measured each time at or near the same location in each plot, with several locations being situated in each plot. Moreover, the moisture determinations must be made at least twice following wetting of the soil by any heavy irrigation or heavy precipitation. To obtain satisfactory results, it is necessary that sufficient time lapse be permitted following thorough wetting of the soil (usually several days) before making the first moisture

determination in a cycle of measurements. Otherwise, moisture moving out of the sampled profile would be incorrectly included as evapotranspiration in the soil moisture depletion measurement.

During the growing season, the general procedure was to sample approximately every seven days, except as modified by irrigation, harvest, or other cultural (farming) operations. During the nongrowing season, measurements were made less frequently because of the lower rates of water use.

At the initiation of the evapotranspiration measuring program in 1955, the gravimetric technique was accepted as the best method available, and was the first technique employed in the studies reported here. Moisture content of soil samples was determined by weight change resulting from moisture loss during oven drying. Soil samples were taken by means of a soil tube, in 1-foot increments of depth, from the soil surface to a depth of 7 or 9 feet. As the soil tube is difficult to handle at depth below 9 feet, sampling below that depth was attempted only in special cases where knowledge of the substratum conditions was desired.

The initial evapotranspiration measurements were made in the mountain valley areas in the northern and northeastern part of the State, and in the northern Sacramento Valley. The objective at that time was to determine the irrigation requirements of only those areas. Plots in the mountain valleys were located on typical irrigated parcels of land. The irrigated lands in this area exist as narrow and isolated "oases" separated by large areas of native vegetation.

From three to eight core holes were made per sampling. This number did not prove to be adequate because of inherent variability of the soils.

During analysis of data collected during the 1955 season, it was determined that observation holes should have been maintained at all plots to determine if water table conditions existed. Through observation holes on a few of the plots, and examination of soil samples taken from the lower profiles, it was found that water tables did exist on some plots where they were not expected. When a water table is present in or near the root zone, there is a probability that the crop will utilize some of this source of moisture. It is impossible to determine this amount.

The greatest problem, however, was that irrigation in some cases added too much water, and in other cases was too infrequent or too little. As previously mentioned, when too much water is applied, downward moisture movement continues for a considerable length of time. A series of field moisture measurements will include both moisture movement, or change, due to plant extraction and evaporation. If too little water is applied, the soil moisture may become critically short, and crop growth may be affected. If the soils become very dry, the evapotranspiration rate may also be affected.

For the next several seasons, work was concentrated on fewer plots, and more detailed observations were made of crop growth, presence of water tables, and other conditions. As the need for irrigation control became recognized as being critical

to obtain adequate evapotranspiration data from soil moisture depletion measurements, attempts to modify irrigation were initiated.

It was observed that weekly visits to plot sites adversely affected the crop cover and soil conditions by trampling the crop. To overcome these undesirable effects, a portable sampling platform was built in 1956 to sample one of the plots. This was the forerunner of platforms which were used later with neutron probes.

In 1957, the water use studies were expanded to other areas of the State. Alfalfa fields were sampled in Stanislaus and Kings Counties. These plots were abandoned because data obtained from them were not considered reliable for estimating evapotranspiration because of excessive moisture movement that resulted from overirrigation at the Stanislaus County plots and unfavorable soil conditions at the plots in Kings County.

In 1958, one man was stationed in Kern County following a reconnaissance for plot sites. Plots of alfalfa, grapes, and plums were sampled. Problems of two kinds were encountered. On plots receiving lesser quantities of irrigation, the crops extracted moisture from below the zone sampled, while on plots receiving very frequent irrigations, considerable moisture movement occurred between sampling.

No further gravimetric samples were taken following the adoption of neutron scattering equipment in the spring of 1959. While complete detailed records were kept and calculations made for each of the gravimetric sampling sites, the results of these measurements are not included in this report.

Field Plot Sampling - Neutron Scattering Technique

A recently developed method to obtain the soil moisture data, referred to as the neutron scattering technique, is based upon the principle that high energy or "fast" neutrons are moderated, or "slowed down," in soils almost exclusively by hydrogen atoms contained in soil moisture. The instrument consists of a source of "fast" neutrons, a detector tube which is sensitive only to "slow" neutrons, and a slow neutron counter. Both source and detector are combined in a cylindrical probe 1.5 inches in diameter by 14 inches long. The probe is lowered into the soil through a small-diameter, cased hole to the desired depth, suspended by its electrical cable. The cable is connected to the counting device which counts pulses produced by slow neutrons returning to the detector. Since the "fast" neutron output of the source is essentially constant, the count recorded in a fixed time period may be used with a suitable calibration to determine the moisture content in the soil surrounding the probe.

The neutron scattering technique has certain advantages over the gravimetric technique. In addition to the ease of making deeper measurements, the neutron measurements take less time, repeatedly represent approximately the same soil mass, and are generally more precise than gravimetric measurements. Measurement of the same soil mass is particularly important, since soil moisture distribution and extraction patterns appear to be nonuniform. It must be noted, however, that overirrigation and resulting moisture movement remain a problem with this method. Also, for greater

accuracy, measurements of the soil surface layer, to a depth of about 1 foot, require a different calibration than the measurements at greater depth below the soil surface. Determination of a suitable calibration is under study by the department and other agencies at this time. It is believed at the present that the error of measuring the losses of water from the soil surface is not large, considering the total water use from the entire profile, in the case of deeper rooted crops.

Inherent variabilities, such as found in physical measurements of any natural phenomenon, occur in soil moisture depletion measurements. Generally, although affecting any given measurement, such variations tend to be compensating and, over a period of time, such as a year, tend to cancel out.

Two neutron scattering devices were acquired in 1958, shortly after this equipment became commercially available. The neutron equipment was used for determination of soil moisture in all field plots since early spring of 1959. The same criteria used for selection of gravimetric sampling plots were followed in establishing the plots sampled with the neutron probe.

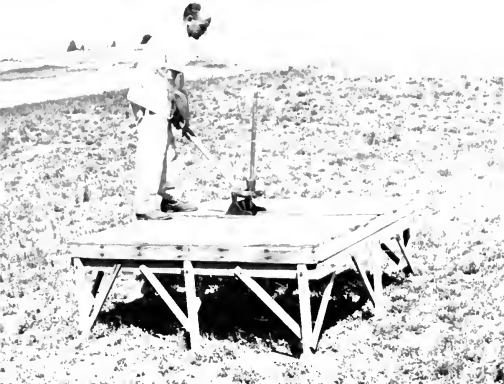
Effort was made to keep the crop in the plot area generally typical of the normal conditions of the entire field. Lightweight, portable sampling platforms with working areas of 15 to 30 square feet were fabricated in 1959 to carry the neutron scattering equipment. These also served as portable working platforms. They have been particularly advantageous in facilitating the field work and in avoiding trampling and injury to the alfalfa and grass crops.

and compaction of the soils. Three types of portable sampling platforms used at Fall River Mills and Bakersfield are shown in Figure 3.

To provide neutron probe access into the soil, thin-walled aluminum tubes 20 feet in length with removable 18-inch extensions at the top were permanently installed flush with the soil surface. Stoppers were placed in the tube at the surface and immediately below the extension to exclude foreign material from the tubes. In this way, the tubes did not extend above the ground to interfere with tillage and crop cultural operations. When tillage operations damaged the upper extensions, they were simply and easily replaced. The access tube design is shown in Figure 4.

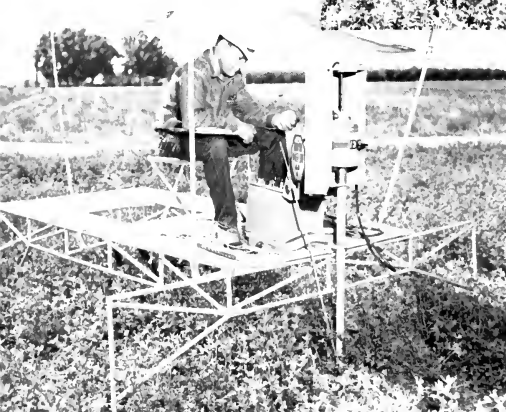
Pittville Neutron Probe Moisture Depletion Measurements.

The Pittville site is located at an elevation of about 3,340 feet, in the northeastern intermountain region, at a latitude of 41 degrees. Selection of the neutron measurement site was preceded by four years of gravimetric sampling in the Fall River Valley and other mountain valleys in the northeastern area. The Pittville 1 S site was sampled using the gravimetric technique in 1956, 1957, and 1958. This prior experience indicated that the Pittville alfalfa field possessed the desirable combination of soil and irrigation conditions for a moisture depletion plot. Topographically, the site is gently sloping with small swales. There is a small ridge 600 feet north of the plot site, which is about 100 feet higher than the plot. The land at the plot site slopes 5 percent



Platform Developed
in Early Stage of
Program for Obtaining
Soil Cores

Small, Wheeled
Platform Used to
Measure Soil
Moisture Depletion
by the Neutron
Scattering Technique



Aluminum Platform
Used with the
Neutron Scattering
Equipment

FIGURE 3. PLATFORMS USED TO MINIMIZE CROP DAMAGE AND SOIL COMPACTION

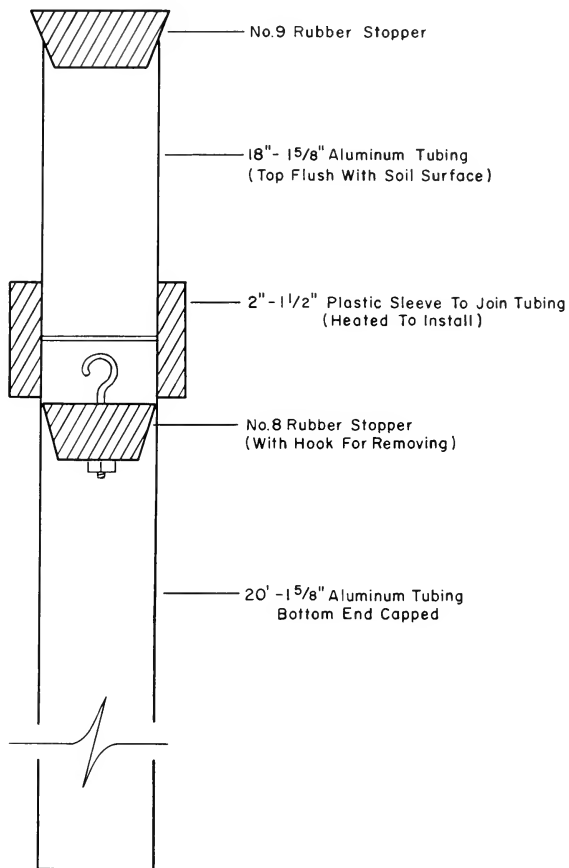


Figure 4, ACCESS TUBE DESIGN

to the south-southwest, and the 30 acres of alfalfa in the field are surrounded by small irrigated fields, dry-farmed grain, and native vegetation. Prevailing winds in the area are from the west

Initially, three rows of five access tubes were installed 75 feet apart, with the tubes spaced in the rows 15 feet apart. In September 1959, four more tubes were installed in one of the rows, and the other two rows abandoned, reducing the plot to nine tubes. This enabled the plot to be irrigated in two days, rather than the three to four days required for the sprinklers to pass over the original three rows of access tubes.

Irrigation water is applied by a portable sprinkler system, using full circle (360 degrees) rotating sprinklers. The sprinklers sometimes stuck in one position, and irrigation application, as a result, was not uniform enough to determine applied water from pumping records. This plot was subjected to somewhat deficit irrigation, which left a dry zone generally below a depth of 8 feet. For this reason, the soil moisture measurements can be used with confidence as estimate of evapotranspiration.

Neutron moisture depletion measurements were made during 1959 and 1960 at another alfalfa site 3 miles west of the Pittville plot. Due to apparent excessive moisture movement, however, the results of these measurements are not included in the report.

Arvin Neutron Probe Moisture Depletion Measurements.

These measurement sites are in the southern San Joaquin Valley, near the 35 degree latitude, located at an elevation of about 440 feet. The plot sites are on broad, smooth, recently formed fans

from the outwash of the Sierra Nevada Range at the southern end of the valley. The land slopes to the southwest at the plot area at about 30 feet per mile (0.6 percent).

Irrigation in the area is supplied from deep wells lifting water several hundred feet. All of the Arvin plots are located on Hesperia fine, sandy loam. This soil has no apparent clay or cemented layers. Moisture drainage is good. Noncontinuous silt layers and pockets of silt of varying thickness are found from 3 feet down to 22 feet below the surface. Plot sites were located where the least amount of silt layers are found. Surrounding the sampling areas were irrigated orchards, vineyards, alfalfa, cotton, and other crops. The irrigated area extends 20 miles to the north, 15 miles to the east, 40 miles to the south, and 60 miles to the west.

Four crops, cotton, alfalfa, plum orchard, and fescue grass, were sampled. All sites were irrigated by furrow or border methods. In order to obtain reasonably precise data, more than 20 sampling tubes were installed on the cotton and alfalfa. Six tubes each were installed on the plums and grass plots for exploratory purposes, the intent being to determine moisture extraction patterns.

The plum orchard is planted on a 24-foot square pattern. Water is applied to five or six straight furrows running in one direction. Results of the neutron probe measurements indicate that the extraction of moisture is greatest from the furrow area near the trees, intermediate from the middle furrows, and least from the soil in the tree rows. Extraction was noted to a depth of 16 feet. Depth of extraction probably depends largely on irrigation practices.

On the grass plot, the moisture was extracted primarily from the upper 2 or 3 feet. With such a large portion of the total water use from such shallow depths, the inherent uncertainty of surface neutron probe measurements assumes greater importance. It has been concluded that the neutron scattering technique is not well suited for measuring evapotranspiration of grasses due to their shallow moisture extraction patterns and frequent irrigations. Plans have been made to use evapotranspirometers on this crop.

On the alfalfa plot, ample tubes were sampled to obtain a good estimate of moisture depletion.

On the cotton plot, three sets of seven tubes each were placed at the upper, middle, and lower ends of the 440-foot furrow runs. The tubes were placed diagonally, crossing the rows, such that the tubes were located in the plant row, and in the furrow bottoms and furrow shoulders. The number of tubes was adequate to determine moisture change with good precision.

Cotton is not normally overirrigated, which is an advantage in soil moisture depletion studies, since soil moisture movement is not as much a problem in data interpretation as with most other crops. Portable water meters were used to measure the water applied to the cotton. These measurements confirmed the seasonal depletion record obtained from the neutron probe measurements.

Evapotranspirometer Measurements

Evapotranspirometers, sometimes referred to as lysimeters, are instruments designed for the measurement of evapotranspiration. They can be of various shapes, sizes, and designs. Essentially,

they are devices which enable the evaluation of the moisture regime of a confined soil mass, of known dimensions, in which a crop is grown. Moisture changes of the crop-soil system are determined by periodic or continuous weighing, or by volumetric determination of water displaced, added, and/or removed from the system.

When used for the determination of field evapotranspiration, it is particularly important that the tanks be installed in such a manner that their presence does not modify the environment of the measured crop. Although this technique appears to be an excellent method for precise measurement of crop water use, certain factors, such as the artificial restriction of crop rooting and possible modification of soil heat transfer, have yet to be completely evaluated. Research on these factors is presently being conducted by the University of California.

The use of evapotranspirometers in the field was not common in California at the initiation of this program, although tanks had been used in the 1920's and 1930's. Because soil moisture depletion studies are not adapted to crops frequently irrigated or having high water tables, small evapotranspirometers were installed to provide a reliable measure of evapotranspiration under those conditions.

Alturas-Dorris Ranch Evapotranspirometer Measurements. In 1956, two small evapotranspirometers were installed near Alturas to measure evapotranspiration from high water table pasture. The plot site was in an irrigated meadow pasture containing high moisture favoring grasses, legumes, and broad-leafed plants found in improved

irrigated pasture mixes and in native mountain meadows. The pasture was grazed nearly continuously by cattle, and was usually short but fully covered the ground. Typical percentages of green growing leaf surfaces were as follows: In April, 40 percent, increasing to 100 percent by the end of the month; May through September, 100 percent; October, 100 percent, decreasing to 50 percent by the end of the month. Cover of green foliage varies between zero and 40 percent during the winter, depending to a large extent upon the severity of the winter. In milder winters, some green live shoots survive, while in severe winters the foliage is completely inactive, and the green color is gone.

The evapotranspirometer site was enclosed by a barbed-wire fence forming a 25- by 75-foot rectangle. Inside the fenced area the grass was mowed several times during the season to maintain approximately a 5-inch height. Two cylindrical steel evapotranspirometers, 36 inches in diameter and 30 inches deep, were installed in the soil within a fenced area, one at each end. Also, inside the plot were a hygrothermograph and evaporation pan, atmometers, phyheliometer, and a precipitation gage.

Water was supplied to the evapotranspirometers by means of a steady, small flow, at a rate calculated to exceed evapotranspiration. It took approximately one week to utilize the water from a cylindrical supply tank 5 feet deep and 18 inches in diameter. A discharge tube was attached to the evapotranspirometer 6 inches below the ground surface, and the excess water not consumed in the transpirometer spilled into a buried sump tank, where it was measured.

The numerous mechanical problems encountered during the first 2.5 years rendered the collected data of questionable validity.

Therefore, these data have not been used for this report. The data collected in 1959 and 1960 are considered representative of evapotranspiration from high water table meadow pasture, and are reported herein.

Coleville Evapotranspirometer Measurements. In 1957, data on high water table meadow pasture were collected from an evapotranspirometer tank near Coleville in the Lassen-Alpine area. The measurement site was located at the eastern edge of the State, at a latitude of about $38^{\circ} 30''$, at an elevation of 5,100 feet. The site was similar to the Alturas-Dorris Ranch site in vegetation and in irrigation methods. The field was subject to long irrigations by wild flooding. The water level at this site varied from 0-16 inches below the ground surface, and was usually about 8 inches below the ground surface. A cylindrical steel evapotranspirometer, 36 inches in diameter by 3 feet deep, was installed. Water was supplied to the evapotranspirometer from a supply tank floated on the water table surrounding the evapotranspirometer. With this system the water table inside the evapotranspirometer was kept at essentially the same level as that in the field. Moisture utilized by the plants was constantly replaced from the supply tank. The level of the supply tank was recorded on a Stevens water stage recorder. The field water table level was also measured on a separate recorder. By integration of the two charts, the rate of evapotranspiration was determined.

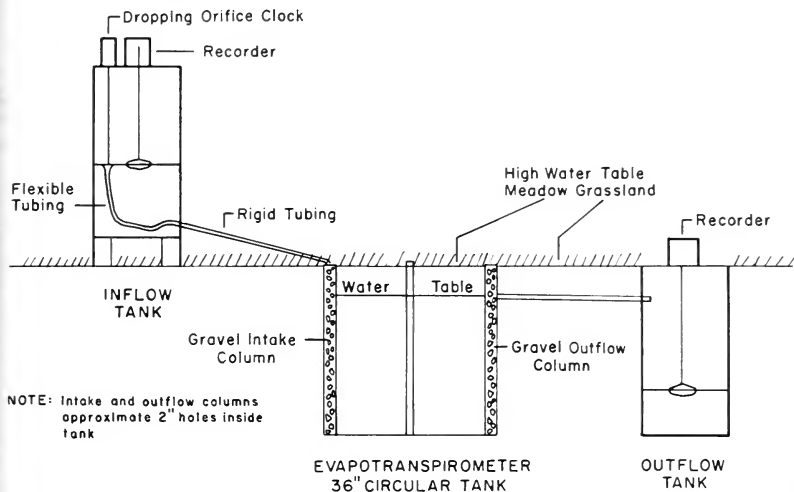
The topography in the area is smooth, with a 2 percent northerly slope. Data were collected at this site for one season in connection with an investigation of water use in watersheds in the eastern Sierra Nevada.

Figure 5 shows diagrammatically the functioning of the Alturas-Dorris Ranch and Coleville evapotranspirometers.

Davis Evapotranspirometer Measurements. In 1958, three small evapotranspirometers 2 feet in diameter were installed at Davis in cooperation with the Department of Irrigation of the University of California. The purpose was to determine how well these small tanks would compare with a large 20-foot diameter tank, which was installed by the university in 1958. Over a 10-month period, the mean evapotranspiration from the 2-foot evapotranspirometers differed less than 5 percent from the 20-foot evapotranspirometer. One reason for this favorable comparison is that both kinds of tanks were located in the same field environment having a continuous, uniform crop height and cover in and around the tanks. The data from the 2-foot evapotranspirometers are presented in this report.

Evapotranspiration Data Summary

Summaries of evapotranspiration for measured and estimated periods are tabulated in Table 5, with corresponding measurements of pan and atmometer evaporation. Evapotranspiration for missing periods was usually estimated as the product of appropriate pan or atmometer coefficients, and pan or atmometer evaporation data collected during these periods, plus calculated increments for surface evaporation following irrigation. Monthly evapotranspiration totals have been computed and are also presented in Table 5. A detailed tabulation of evapotranspiration and related data are presented in Tables A-6 and A-7 of Appendix A, for the approximately weekly measurement schedule. Variability of soil moisture values



ALTURAS - DORRIS RANCH EVAPOTRANSPIROMETER

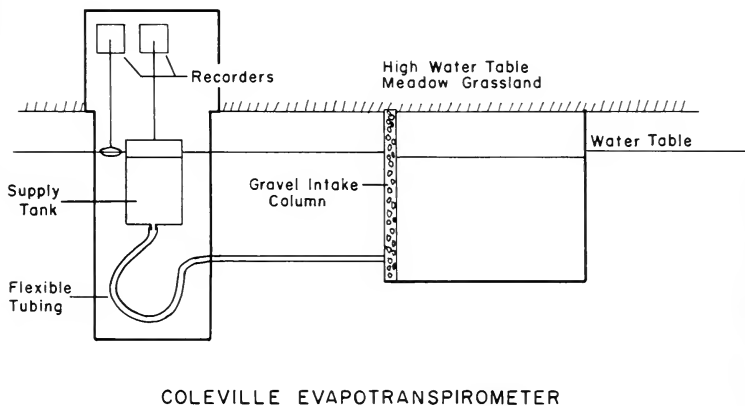


Figure 5, EVAPOTRANSPIROMETER DESIGN

TABLE 5

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA

		Evapotranspiration				Pan evaporation			Atmometer evaporation		
		Meas-	Esti-	Accum.	Monthly	Each	Accum.	Monthly	Each	Accum.	Monthly
Year	Month	Period	ured	mated	totals	est.	period	totals	est.	period	totals
Sacramento River Mountain Valleys											
Pasture - Alturas - Dorris Ranch											
1959	Apr.	4/7 - 4/30		4.03	4.03		4.35	4.35			
		3/31- 4/30			5.15				5.54		
	May	4/30- 5/31		5.99	10.02	5.99	6.09	10.44	6.09		
	June	5/31- 6/30		8.95	18.97	8.95	7.94	18.38	7.94		
		6/2 - 6/30		(8.33)						510	510
	July	6/30- 7/31		10.45	29.42	10.45	9.83	28.21	9.83	645	1,155
	Aug.	7/31- 8/31		9.04	38.46	9.04	8.65	36.86	8.65	547	1,702
	Sept.	8/31- 9/30		4.90	43.36	4.90	5.41	42.27	5.41		
		8/31- 9/22		(3.78)						315	2,017
	Oct.	9/30-11/2		3.02	46.38	2.85	3.80	46.07	3.59		
TOTALS		4/7 -11/2		46.38			46.07				
		6/2 - 9/22		31.60						2,017	
1960	Apr.	4/8 - 5/1		2.33	2.33	2.99	3.50	3.50	4.53		
	May	5/1 - 5/31		4.61	6.94	4.78	5.71	9.21	5.90		
	June	5/31- 6/7			1.96	8.90	1.96				
		6/7 - 6/14		1.41	10.31		1.73	12.90		129	129
		6/14- 6/21			1.96		1.96			116	
		6/21- 6/28		1.62	13.89		1.98	16.84		140	385
		5/31- 6/30				6.56			8.00		
	July	6/28- 8/1		10.33	24.22		9.45	26.29		608	993
		6/30- 7/31				9.61			8.82		
	Aug.	8/1 - 8/31		8.99	33.21		8.02	34.31		480	1,473
		7/31- 8/31				9.31			8.31		
	Sept.	8/31- 9/30		6.01	39.22	6.01	5.91	40.22	5.91	421	1,894
	Oct.	9/30-10/31		3.56	42.78	3.56	3.81	44.03	3.81		
		9/30-10/3		(0.47)						43	1,934
	Nov.	10/31-11/21			0.71	43.49		0.76			
		11/21-12/1		0.17	43.66		0.38	45.17			
		10/31-11/30				0.51			0.76		
	Dec.	12/1 -12/31		0.75	44.41		0.62	45.79			
		11/30-12/31				0.78			0.65		
TOTALS		4/8 -12/31		39.78			41.11				
		6/7 -10/3		28.83						1,821	

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

			Evapotranspiration				Pan evaporation			Atmosphere evaporation		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
Year	Month	Period										
<u>Sacramento River Basin Valley Floor</u>												
<u>Pasture - Davis Campbell</u>												
1959	Jan.	12/31- 2/2	1.42		1.42		2.03	2.03				
		12/31- 1/31				1.15				1.65		
	Feb.	2/2 - 2/27	2.27		3.69		2.18	4.21				
		1/31- 2/28				2.56				2.65		
	Mar.	2/27- 4/1	4.45		8.14		6.57	10.78				
		2/28- 3/31				4.31				6.32		
	Apr.	4/1 - 4/16	2.51		10.65		4.26	15.04				
		4/16- 4/30		1.82	12.47		2.23	17.27				
		3/31- 4/30				4.45				7.55		
	May	4/30- 5/14	2.87		15.34		4.34	21.61				
		5/14- 5/21		1.56	16.90		2.56	24.17				
		5/21- 5/28	1.06		17.96		1.91	26.08				
		4/30- 5/31				6.05				9.75		
	June	5/28- 6/8		2.19	20.15		3.67	29.75				
		6/8 - 6/15	1.67		21.82		2.23	31.98				
		6/15- 6/30		4.08	25.90		5.72	37.70				
		5/31- 6/30				7.38				11.02		
	July	6/30- 7/29	8.11		34.01		10.74	48.44				
		6/30- 7/31				8.74				11.15		
	Aug.	7/29- 8/31	7.65		41.66		9.88	58.32				
		7/31- 8/31				7.02				9.13		
	Sept.	8/31- 9/3		0.76	42.42		0.59	58.91				
		9/3 -10/2	5.63		48.05		8.23	67.14				
		8/31- 9/30				5.97				8.14		
	Oct.	10/2 -11/2	4.26		52.31		6.66	73.80				
		9/30-10/31				4.56				7.11		
	Nov.	11/2 -12/5	2.12		54.43		4.19	77.99				
		10/31-11/30				1.92				3.53		
	Dec.	12/5 -12/31	0.88		55.31		1.68	79.67				
		11/30-12/31				(1.25)				2.65		
TOTALS		12/31/58-12/31/59	44.90				64.90					
1960	Jan.	12/31- 1/30	0.84		0.84		1.48	1.48				
		12/31- 1/31				0.88				1.63		
	Feb.	1/30- 2/26	1.53		2.37		2.86	4.36				
		1/31- 2/29				1.78				3.08		

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration				Pan evaporation			Atmometer evaporat		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Mon
1960	Mar.	2/26- 3/31	3.35		5.72		4.21	8.57				
		2/29- 3/31				3.06				3.86		
	Apr.	3/31- 4/29	4.85		10.57		5.65	14.22				
		4/18- 4/29	(1.73)								138	138
		3/31- 4/30				5.27				6.11		
	May	4/29- 6/1	7.50		18.07		9.20	23.42				
		4/30- 5/31				7.10				8.74	570	708
	June	6/1 - 7/1	5.87		23.94		12.02	35.44				
		5/31- 6/30				5.87			12.02		607	1,315
	July	7/1 - 7/19	4.25		28.19		6.44	41.88			390	1,705
TOTALS		12/31- 7/19	28.19				41.88					
		4/18- 7/19	19.35								1,705	

Lassen - Alpine Mountain ValleysPasture - Coleville - 2E

1957	May	5/27- 6/3	1.34		1.34		1.38	1.38				
	June	6/3 - 6/30	6.91		8.25		7.31	8.69				
		5/31- 6/30				7.53				7.95		
		6/10- 6/30	(5.23)								434	434
	July	6/30- 8/1	9.12		17.37	9.12	9.33	18.02	9.33		601	1,035
	Aug.	8/1 - 8/31	7.76		25.13	7.76	9.09	27.11	9.09		583	1,618
	Sept.	8/31- 9/23	3.39		28.52		4.63	31.74			359	1,977
TOTALS		5/27- 9/23	28.52				31.74					
		6/10- 9/23	25.50								1,977	

Sacramento River Basin Mountain ValleysAlfalfa - Fall River Mills - Plot AA

1959	Mar.	3/17- 4/8	1.92		1.92							
		3/17- 3/31				1.26						
	Apr.	4/8 - 4/23	3.86		5.78							
		4/23- 4/30		1.34	7.12							
		3/31- 4/30				5.86						
	May	4/30- 5/6	1.33		8.45							
		5/6 - 5/28	4.24		12.69							
		4/30- 5/31				6.76						
	June	5/28- 7/2	8.48		21.17						715	715
		5/31- 6/30				6.88						
	July	7/2 - 7/6	1.27		22.44						86	801
		7/6 - 7/27	6.41		28.85						463	1,264
		7/27- 7/31	0.95		29.80						70	1,334
		6/30- 7/31				9.04						

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration				Pan evaporation			Atmometer evaporation		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
1959	Aug.	7/31- 8/3			0.86	30.66				59	1,393	
		8/3 - 8/14	1.81		32.47					232	1,625	
		8/14- 8/31			3.58	36.05				355	1,980	
		7/31- 8/31				6.25						646
	Sept.	8/31- 9/3			0.92	36.97				65	2,045	
		9/3 - 9/15	3.49		40.46					207	2,252	
		9/15- 9/30			2.51	42.97				209	2,461	
		8/31- 9/30				6.92						481
TOTALS		3/17- 9/30	30.21									
		5/28- 9/30	20.19							1,617		

Sacramento River Basin Mountain ValleysAlfalfa - Fall River Mills - Plot AA

1960	Mar.	3/10- 4/19	3.71		3.71		5.91	5.91				
		3/10- 3/31				1.90			3.80			
	Apr.	4/19- 5/11	2.39		6.10		3.82	9.73				
		3/31- 4/30				2.83			4.65			
	May	5/11- 5/19		2.37	8.47		2.25	11.98				
		5/19- 6/3	3.31		11.78		2.91	14.89				
		4/30- 5/31				6.42			6.67			
	June	6/3 - 6/24	3.29		15.07		6.20	21.09				
		6/10- 6/24	(1.21)							275		
		6/24- 6/30		1.28	16.35		1.64	22.73		121	396	
		5/31- 6/30				5.57			8.69			588
	July	6/30- 7/25	7.85		24.20		8.61	31.34		492	888	
		7/25- 8/1		0.92	25.12		2.09	33.43		114	1,002	
		6/30- 7/31				8.40			10.40			584
	Aug.	8/1 - 8/5		1.06	26.18		1.33	34.76		80	1,082	
		8/5 - 8/26	6.30		32.48		6.41	41.17		375	1,457	
		8/26- 9/1		1.52	34.00		1.46	42.63		97	1,554	
		7/31- 8/31				8.88			9.20			550
	Sept.	9/1 - 9/28	4.55		38.55		5.41	48.04		425	1,979	
		8/31- 9/30				5.10			5.85			452
	Oct.	9/28-11/8	4.82		43.37		5.05	53.09				
		9/30-10/31				3.80			3.97			
TOTALS		3/10-11/8	36.22				44.32					
		6/10- 9/28	19.91							1,567		

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

		Evapotranspiration				Pan evaporation				Atmometer evaporation			
		Meas.	Esti.	Accum.	Monthly	Each	Accum.	Monthly	Each	Accum.	Monthly	Each	Accum.
Year	Month	Period	used	dated	totals	est.	period	totals	est.	period	totals	est.	period
<u>Tulare Lake Basin Valley Floor</u>													
<u>Alfalfa - Arvin - Plot CC</u>													
1959	Mar.	3/13- 3/27	1.07		1.07		2.28	2.28		186	186		
		3/27- 4/3		1.06	2.13		1.35	3.63		106	292		
		- 3/31							4.53				
	Apr.	4/3 - 4/21	2.54		4.67		4.16	7.79		293	585		
		4/21- 4/28		1.16	5.83		1.77	9.56		100	685		
		3/31- 4/30				4.49			7.00				
	May	4/28- 5/14		2.34	8.17		3.82	13.38		244	929		
		5/14- 5/25	1.31		9.48		2.96	16.34		172	1,101		
		5/25- 6/1		1.34	10.82		2.58	18.92		123	1,224		
		4/30- 5/31				4.54			8.69				
	June	6/1 - 6/9	2.06		12.88		2.45	21.37		148	1,372		
		6/9 - 6/15		0.93	13.81		1.81	23.18		112	1,484		
		6/15- 6/22	1.00		14.81		2.13	25.31		142	1,626		
		6/22- 6/29		1.45	16.26		2.22			132	1,758		
		5/31- 6/30				5.80			9.06				
	July	6/29- 7/3	1.09		17.35		1.58	29.11		88	1,846		
		7/3 - 7/8		0.90	18.25		1.54	30.65		102	1,948		
		7/8 - 7/17	1.20		19.45		2.71	33.36		170	2,118		
		7/17- 7/22		1.10	20.55		1.37	34.73		84	2,202		
		7/22- 7/29	1.70		22.25		2.30	37.03		126	2,328		
		6/30- 7/31				6.34			9.95				
	Aug.	7/29- 8/8		2.38	24.63		2.83	39.86		168	2,496		
		8/8 - 8/13	0.39		25.02		1.67	41.53		102	2,598		
		8/13- 8/27		2.56	27.58		3.50	45.03		220	2,818		
		7/31- 8/31				6.07			8.67				
	Sept.	8/27- 9/15	3.86		31.44		3.96	48.99		312	3,130		
		9/15- 9/22		1.30	32.74		1.40	50.39		106	3,236		
		9/22-10/2	1.74		34.48		2.11	52.50		158	3,394		
		8/31- 9/30				5.27			5.93				
	Oct.	10/2 -10/9		0.90	35.38		1.04	53.54		96	3,490		
		10/9 -10/21	1.29		36.67		1.72	55.26		172	3,662		
		10/21-11/3		1.04	37.71		1.65	56.91		135	3,797		
		9/30-10/31				3.22			4.49				
	Nov.	11/3 - 12/2	2.52		40.23		2.49	59.40					
		10/31-11/30				2.76			2.69				
	Dec.	12/2 - 1/5	2.01		42.24		1.76	61.16					
		11/30-12/31				1.87			1.68				
TOTALS		3/13- 1/5	23.78				34.28						
		3/13-10/21	19.25							2,069			

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

Year	Month	Period	Evapotranspiration				Pan evaporation			Atmometer evaporation		
			Meas- ured	Esti- mated	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.	Each period	Accum. totals	Monthly est.
1960	May	5/12- 5/31	2.98		2.98		5.58	5.58		354	354	
	June	5/31- 6/24		6.69	9.67		8.24	13.82		541	895	
		6/24- 7/1	1.01		10.68		1.93	15.75		138	1,033	
		5/31- 6/30				7.67			9.98			670
	July	7/1 - 7/8		1.44	12.12		2.27	18.02		151	1,184	
		7/8 - 8/1	4.56		16.68		7.13	25.15		488	1,672	
		6/30- 7/31				6.00			9.39			639
	Aug.	8/1 - 8/10		1.36	18.04		2.53	27.68		180	1,852	
		8/10- 9/1	5.27		23.31		5.56	33.24		402	2,254	
		7/31- 8/31				6.63			8.09			582
	Sept.	9/1 - 9/16		1.67	24.98		3.19	36.43		251	2,505	
		9/16- 9/22	1.58		26.56		1.19	37.62		98	2,603	
		9/22- 9/29		0.72	27.28		1.44	39.06		108	2,711	
		8/31- 9/30				4.10			6.13			480
	Oct.	9/29-10/27	2.42		29.70		3.85	42.91		341	2,052	
		9/30-10/31				2.59			4.08			372
	Nov.	10/27-11/18	0.87		30.57		1.60	44.51		179	3,231	
TOTALS			5/12-11/18	18.69			26.84			2,000		

Tulare Lake Basin Valley FloorCotton - Arvin - Plot CD

1959	May	4/30- 5/8		0.13	0.13		1.68	1.68		117	117	
		5/8 - 5/21	0.32		0.45		3.88	5.56		217	334	
		5/21- 6/3		1.54	1.99		3.76	9.32		210	544	
		4/30- 5/31				1.58			8.69			498
	June	6/3 - 6/16	1.88		3.87		4.19	13.51		252	796	
		6/16- 6/23		2.51	6.38		2.16	15.67		153	949	
		6/23- 6/30	2.67		9.05		2.11	17.78		126	1,075	
		5/31- 6/30				7.47			9.06			571
	July	6/30- 7/7	2.41		11.46		2.43	20.21		138	1,213	
		7/7 - 7/15		2.79	14.25		2.56	22.77		159	1,372	
		7/15- 7/28	4.55		18.80		4.02	26.79		236	1,608	
		6/30- 7/31				10.67			9.95			582
	Aug.	7/28- 8/4	2.31		21.11		2.23	29.02		126	1,734	
		8/4 - 8/11		1.86	22.97		2.15	31.17		131	1,865	
		8/11- 8/18	1.38		24.35		1.91	33.08		125	1,990	
		8/18- 8/25		1.50	25.85		1.63	34.71		106	2,096	
		8/25- 9/2	2.22		28.07		2.23	36.94		146	2,242	
		7/31- 8/31				7.76			8.67			548
	Sept.	9/2 - 9/24	3.85		31.92		4.18	41.12		338	2,580	
		8/31- 9/30				5.10			5.93			473

TABLE 5 (continued)

SUMMARY OF MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA (Continued)

		Evapotranspiration				Pan evaporation			Atmosphere evaporation			
		Meas.	Esti.	Accum.	Monthly	Each	Accum.	Monthly	Each	Accum.	Monthly	
Year	Month	Period	ured	mated	totals	est.	period	totals	est.	period	totals	est.
1959	Oct.	9/24-10/19	3.68		35.60		4.21	45.33		372	2,952	
	Defoliated											
		10/19-11/4	0.36		35.96		2.01	47.34		163	3,115	
		9/30-10/31				2.95			4.49			41
	Nov.	11/4 -12/17	0.33		36.29		3.21	50.55				
		10/31-11/30				0.19			2.69			
TOTALS		5/8 -12/17	25.96				36.61					
		5/8 -11/4	25.63							2,239		

Tulare Lake Basin Valley FloorCotton - Arvin - Plot CF

1960	Mar.	3/18- 3/23		0.50	0.50		0.85	0.85				
	Planted	4/6										
	Apr.	3/23- 5/6	1.46		1.96		8.40	9.25		634	634	
		3/31- 4/30				0.83			5.82			43
	May	5/6 - 6/9	0.37		2.33		10.39	19.64		666	1,300	
		4/30- 5/31				0.31			8.72			57
	June	6/9 - 6/15	0.84		3.17		2.03	21.67		131	1,431	
		6/15- 6/20		1.81	4.98		1.82	23.49		124	1,555	
		6/20- 6/30	2.41		7.39		3.20	26.69		226	1,781	
		5/31- 6/30				5.31			9.98			67
	July	6/30- 7/7	1.94		9.33		2.13	28.82		138	1,919	
		7/7 - 7/15		2.63	11.96		2.54	31.36		179	2,098	
		7/15- 7/28	4.15		16.11		3.59	34.95		249	2,347	
		6/30- 7/31				10.14			9.39			63
	Aug.	7/28- 8/9		4.25	20.36		3.44	38.39		234	2,581	
		8/9 - 8/19	3.28		23.64		2.62	41.01		198	2,779	
		8/19- 8/23		1.43	25.07		1.34	42.35		86	2,865	
		8/23- 8/31	1.29		26.36		1.71	44.06		127	2,992	
		7/31- 8/31				8.87			8.09			58
	Sept.	8/31- 9/21	4.35		30.71		4.61	48.67		346	3,338	
		8/31- 9/30				5.04			6.13			48
	Oct.	9/21-10/14	1.79		32.50		3.96	52.63		318	3,656	
	Defoliated	-10/19										
		9/30-10/31				1.03			4.08			37
	Nov.	10/14-11/22	0.94		33.44		3.45	56.08		365	4,021	
		10/31-11/22				1.02			1.89			21
TOTALS		3/23-11/22	22.82				46.09			3,398		

obtained during any one period of depletion is expressed in Table A-6 under the heading "Twice the Standard Error."

The effects of percent ground cover and, possibly, of stage of crop maturity and available soil moisture, are illustrated in Plate 3, which compares accumulated evapotranspiration of different crops. These measurements were made in the Arvin area under similar climatic conditions and on the same soil series. Differences in percent ground cover and possibly crop maturity and available soil moisture cause differences in slopes of the curves shown in Plate 3. Defoliation caused the abrupt changes in evapotranspiration rates reflected in the curves on cotton and plums. Alfalfa remains green at this location throughout the year, and shows little seasonal slope changes. It is of interest to note the much higher July and August rates of evapotranspiration by cotton, as compared to alfalfa and plums in both 1959 and 1960. A complete explanation for this cannot be presented; however, certain of the factors affecting evapotranspiration are discussed in the following chapter.



CHAPTER IV. CORRELATION OF EVAPOTRANSPIRATION DATA WITH AGROCLIMATIC DATA

To attempt concurrently to measure evapotranspiration of the many species of irrigated crops presently grown in California is impractical because of financial and manpower requirements. Likewise impractical is the measurement of evapotranspiration of a single crop at more than a few locations.

The most promising approach at this time appears to be to determine the important and measurable parameters affecting evapotranspiration rates, and to correlate actual measurements of evapotranspiration with those parameters. Three important parameters which appear independently to affect evapotranspiration are climate, plant conditions, including physiological factors, and soil moisture availability. Differences in the physical and chemical properties of soils and soil fertility are not considered to directly affect evapotranspiration, even though they may have indirect effects.

This chapter discusses the relationship of each of those parameters of evapotranspiration, and summarizes the analysis of data collected through 1960. In this regard, basic research on factors affecting evapotranspiration is being conducted by the University of California, as an integral part of the Vegetative Water Use Program. The Agricultural Research Service is also conducting basic research in this field. The results of these research programs have affected, and shall continue to influence, the course of these studies.

Evapotranspiration and Climatic Data

Climate in the evapotranspiration process can be thought of as a combination of evaporative elements, such as air temperature, wind, dryness of the air, and solar radiation. Other factors of climate, such as length of daylight, may be indirectly related to evaporation.

The energy sources for the evapotranspiration processes are derived principally from direct solar radiation and advection or exchangeable heat from the air. The evaporative demand of the atmosphere is largely a function of those two elements. However, not all of the solar radiation that falls directly on the plant or ground surface is used in evapotranspiration. A portion is reflected back into the atmosphere, a portion is utilized in heating the air, a portion is absorbed in heating the soil, and the balance is utilized in evapotranspiration and plant growth. It is likewise probable that the energy available from advection is not all utilized, depending upon many factors, such as vapor pressure deficit and extent of wind movement. Under certain conditions, it has been demonstrated that advective cooling, as well as advective heating may occur.

As the moisture content of the air increases through evaporation and/or transpiration, the moisture gradient (vapor pressure gradient) between an air mass and an evaporating surface becomes less steep and retards further moisture transfer. Under field conditions, the air mass near the ground is far from stable. Air movements act to mix moisture-saturated air near the evaporating

surface with drier air from above. Wind speeds and surface roughness influence the relative turbulence of the air, moving the moisture away from the evaporating surface and bringing in drier air to further the evaporation process. Thus, it is apparent that the evaporative demand of the atmosphere is determined by the interaction of several climatic elements.

Progress is being made in determining the relationships between the aforementioned climatic factors to arrive at a quantitative approach to estimating evapotranspiration.

Evapotranspiration and Plant Conditions

The term "evapotranspiration" implies the sum of evaporation plus transpiration. In the case of plants that are actively growing and well supplied with moisture, transpiration is related and responsive to climatic conditions. Evaporation from soils, however, is related more closely to, and limited by, the moisture content of the exposed soil surface than to climatic conditions. In most irrigated areas in California, rain is sparse during the growing season and, except for areas of high water tables, soil surfaces soon dry through evaporation following irrigation. As a result, under California irrigation conditions, transpiration is usually the larger of the two components comprising evapotranspiration.

The primary plant parameter affecting evapotranspiration rate appears to be the percent of ground cover. This is an important consideration when determining evapotranspiration for annual field crops, such as sugar beets and cotton, and for other

crops having variable ground cover percentages, such as alfalfa, which is cut frequently.

Crops having rapid growth rates and vigor tend to provide greater ground cover more rapidly than a slow-growing crop, even of the same species. Thus, differences in growth rate may affect evapotranspiration rates through the direct mechanism of percent of ground cover, although other physiological factors, such as stage of maturity or growth, may also affect evapotranspiration.

Evapotranspiration and Soil Moisture

Research findings relative to the effect of variations of available soil moisture upon evapotranspiration and plant growth are varied.

The amount of soil moisture available above the permanent wilting point does not seem to affect the evapotranspiration rate of crops, according to many research reports. Other research has indicated that maximum growth rates are obtained only under conditions of high moisture availability, and that growth rates and yields are retarded as soil moisture availability decreases. These concepts differ from other research investigations which have indicated a close relationship between evapotranspiration and plant growth. These concepts are of particular importance in considering if evapotranspiration rates are affected by low soil moisture levels which appear to affect growth rates, such as occur when irrigation is deliberately withheld from grapes and cotton to change their fruiting characteristics.

Besides intentional withholding of irrigation, there are also occasions of drought due to insufficient irrigation water

supplies. Due to the foregoing reasons, crops are frequently subjected to drought for periods of time varying from a few hours up to several weeks.

Therefore, in the studies reported here, an evaluation was made of the effect of available moisture upon evapotranspiration.

Available moisture was determined for the principal root zone for each crop from selected neutron probe soil moisture data. In the case of the alfalfa, a perennial crop, a single zone from 0-12 feet was used for the entire study. For cotton, an annual crop, the zone was increased from the 0-1-foot depth to the 0-11-foot depth as the crop grew and the root system developed and expanded. The results of the evaluations are discussed further under the sections on crop coefficients.

Other Factors Affecting Evapotranspiration

Soil fertility and other physical factors of the soil, such as texture, structure, salinity, and even color, affect the growth rate of a crop. Soil properties, such as texture, structure, and salinity may also affect, to some degree, moisture movement and utilization. These factors have an undetermined, and probably much lesser, effect on evapotranspiration than drought, climate, and plant conditions.

Determination of Coefficients

Results of various research projects have indicated that the processes of evapotranspiration and evaporation are both responsive to the same factors. As will be discussed in ensuing

paragraphs, a definite relationship exists between evapotranspiration and rates of evaporation from pans or atmometers. This relationship is considered fundamental to estimating evapotranspiration for other crops and in other agricultural areas throughout the State.

The ratio of evapotranspiration (ET) to evaporation from an evaporation pan (Ep) is referred to as a "pan coefficient" (ET/Ep); in like manner, the ratio of evapotranspiration to net atmometer evaporation, or the difference of evaporation from a black and white Livingston Spherical Atmometer (Eb-w), is referred to as the "atmometer coefficient" (ET/eb-w).

Pan and/or atmometer coefficients for individual evapotranspiration measurement periods for the various plots sampled are shown in Appendix A in Tables A-6 and A-7. A casual examination of these individual periods reveals wide variations which would appear to discount the validity of such comparisons. However, a more detailed analysis of the data indicates that certain relationships do exist, and upon such relationships tentative values can be established. Certain variations of the pan and atmometer coefficients from time to time are caused by plants responding differently to evaporation influences than do pans and atmometers. Likewise, variations in the coefficients were due also to individual differences in the response of atmometers or pans to these climatic influences.

Analysis of data for each individual crop and the conclusions drawn therefrom are discussed in the following paragraphs

Grass and Pasture Coefficients

Pan and atmometer coefficients have been determined using data from grass and grass-pasture evapotranspirometer tanks located in the Sacramento River Basin mountain valleys, in the Lassen-Alpine mountain area, and in the Sacramento Valley floor (Alturas, Coleville, and Davis).

Graphs of coefficients and percent of ground cover for pasture and grass, plotted against time, are presented in Figures A through E of Plate 4, entitled "Variation of Pan and Atmometer Coefficients for Individual Periods of Measurements." Percent of ground cover is relatively constant for those crops, and wide variations of the coefficients occur less than with alfalfa and cotton. During the growing period, the grass was at nearly 100 percent ground cover in all of the evapotranspirometer tanks, as mowings did not clip the foliage short enough to cause large reductions in ground cover. While the ground was always sod-covered, the colder climate at the mountain sites caused dormancy to some degree during late fall, winter, and early spring. Approximate ground cover percentages indicated on Figures A, B, and E of Plate 4 are for the green and actively growing fraction of the foliage. At Davis, the climate is not cold enough to force the grass completely into winter dormancy. Occasionally at the Davis site, however, small areas of ground surface were exposed throughout the year, as indicated on Plate 4, Figures C and D.

High water table conditions, typical of the predominant irrigation practice in the mountain valleys, were maintained in the Alturas and Coleville tanks. There was, therefore, no

moisture shortage at these sites. The evapotranspirometer tanks and ryegrass field at Davis were frequently irrigated, and it is probable that soil moisture was not limiting there. Availability of soil moisture is assumed to have had little effect on evapotranspiration rates and coefficients at any of the three sites.

Seasonal accumulated evapotranspiration plotted against accumulated pan evaporation and, except for Davis, accumulated atmometer evaporation are shown on Plate 5, entitled "Comparison of Pan and Atmometer Coefficients for Cotton, Alfalfa, and Grass," Figures E and F. Each curve is for an individual year, and has separate zero lines for plotting evapotranspiration. Evaporation from pans or atmometers was plotted using the date of June 30 as the common point on all curves. Coefficients for the period of record for both years were consistently similar for Alturas for both pan and atmometer. The pan coefficient for the period of record at Davis was likewise similar.

Coefficients from three seasons of record in the mountain areas, combining Alturas and Coleville, are compared with coefficients from Davis in Table 6. Coefficients are shown for both the growing seasons assumed in Bulletin No. 2 and for the longer period for which data were obtained. The reason for the differences between the valley and mountain coefficients has not been ascertained.

Alfalfa Coefficients

Pan and atmometer coefficients have been determined from an alfalfa plot located near Pittville in the Sacramento River Basin mountain valleys, and from an alfalfa plot near Arvin in the Tulare Lake Basin Valley floor at the southern end of the Central Valley.

PAN AND ATMOMETER COEFFICIENTS FOR PASTURE AND GRASS

Month	Pan Coefficients			Atmometer Coefficients		
	Sacramento River	Mountain Valleys/	Sacramento River	Mountain Valleys/	Alturas Dorris Ranch	Alturas Dorris Ranch
	Basin Valley Floor	(Alturas Dorris Ranch	Basin Valley Floor	(Alturas Dorris Ranch	Basin Valley Floor	Alturas Dorris Ranch
	(Davis Campbell	1959 & 1960	(Davis Campbell	1959 & 1960	(Davis Campbell	1959 & 1960
	1959 & 1960)	Coleville 1957)	1959 & 1960)	Coleville 1957)	1959 & 1960)	Coleville 1957)
	No. Days	No. Days	No. Days	No. Days	No. Days	No. Days
	: of Record :	: of Record :	: of Record :	: of Record :	: of Record :	: of Record :
	ET/Ep*	ET/Ep	ET/Ep*	ET/Ep	ET/Ep*	ET/Ep
January	63	0.64	--	--	--	--
February	52	0.75	--	--	--	--
March	67	0.72	--	--	--	--
April	44	0.74	46	0.81	11	0.0125
May	54	0.74	65	0.90	33	0.0132
June	7	0.75	74	1.00	--	--
July	47	0.72	96	1.04	47	0.0127
August	33	0.77	92	1.00	--	62
September	29	0.68	83	0.90	29	0.0161
October	31	0.64	64	0.87	31	0.0160
November	33	0.51	10	0.45	10	0.0109
December	26	0.52	30	1.21	--	--
Average						
Coefficient						
for Growing						
Season ²	245	0.72 ^a	410	0.98 ^b	151	0.0120 ^c
Period of						
Record	486	0.71	560	0.96	161	0.0148 ^b

1/ Mountain Valleys = Sacramento River Basin Mountain Valleys and Lassen-Alpine Mountain Valleys.

2/ For growing season periods used in Bulletin No. 2.

a/ April-October

b/ May-September

* ET/Ep = Pan Coefficient, ET/Ep-w = Atmometer Coefficient

One of the most notable details of the alfalfa coefficients determined from both areas is the variation associated with percentage of ground cover. It is important to point out that the method of collecting data on percentage of ground cover was subjective, being based upon personal judgment, and that estimates by individual observers differ by perhaps 5 to 15 percent. There is, however, general agreement that following mowing the ground cover is usually reduced to 5 to 10 percent, and that ground cover usually approaches 100 percent cover prior to mowing. Although there are exceptions due to possible experimental error and other factors, the coefficients are smaller when the ground cover is low following mowing, and become larger as the ground cover increases. Plate 4, Figures F, G, H, and I, illustrate these relationships between coefficients and percent of ground cover, plotted against time.

A more direct comparison of pan and atmometer coefficients with percent of ground cover is shown in Plate 6, entitled "Relationship Between Pan and Atmometer Coefficients for Alfalfa and Ground Cover." Figure A shows atmometer coefficients, and Figure B shows pan coefficients. The data for both figures were the same utilized in Plate 4. As indicated in Plate 6, the Pittville coefficients appear to be higher than the Arvin coefficients. Two linear regression lines have been fitted to the data. However, it may be that additional data will indicate a somewhat curvilinear relation. It seems reasonable to assume that coefficients at 100 percent of ground cover would not be proportionally higher than coefficients at 80 percent of ground cover, which, for practical purposes, also provide nearly complete shade, except near noonday.

Since the soil at both plot sites was deep, and alfalfa is a perennial crop, moisture in the 0-12-foot zone was used to estimate available soil moisture.

The lowest moistures occurred at the Pittville plot, where on several occasions the available moisture was reduced to less than 2 inches in the 12 feet, or less than 0.2 inch of moisture per foot of soil, on the average. When this condition occurred, the upper portion of the profile was usually relatively drier than the deeper soil. On several of these occasions, crop growth at the Pittville plot was slow, and considerable flower blooms and dark blue-green leaf color associated with moisture deficiency appeared. As indicated on Figures F and G of Plate 4, low available soil moisture may account for some of the smaller coefficients noted prior to mowing. The Arvin plot, in contrast, was very well supplied with soil moisture. As shown on Figures H and I, the available moisture at Arvin ranged above 1 and up to 2 inches per foot during the measurement periods.

If evapotranspiration were reduced by low available soil moisture, the pan and atmometer coefficients would be smaller. This does not appear to be the case for the Pittville plot, although several of the coefficients just prior to mowing are smaller than would be expected, considering the percent of ground cover. Overall, the pan and atmometer coefficients of the Pittville data are as high, if not higher, than the Arvin coefficients, regardless of the lower soil moistures at Pittville.

Since coefficients from the Pittville and Arvin plots show monthly variations reflecting mowing schedules, farm practices,

and, perhaps, effects of plant growth environments, it is deemed best to compare seasonal rather than monthly coefficients.

Seasonal coefficients have been determined for periods when evapotranspiration measurements were made using data shown in Table 5, and are summarized here as follows:

Seasonal Alfalfa Coefficients Determined
From Measured Periods Only

	<u>Pan Coefficient</u>		<u>Atmometer Coefficient</u>	
	<u>1959</u>	<u>1960</u>	<u>1959</u>	<u>1960</u>
Pittville	nr	0.82	0.0125	0.0127
Arvin	0.69	0.70	0.0093	0.0093

In order to take into account the possibility that the sampling periods could be biased and not representative of ground cover conditions, and also to include estimated evaporation increments following irrigations, estimates of evapotranspiration were made for the irrigation periods. These estimates fill in the missing records. Seasonal coefficients determined from these data are summarized as follows:

Seasonal Alfalfa Coefficients,
Including Estimated Data

	<u>Pan Coefficient</u>		<u>Atmometer Coefficient</u>	
	<u>1959</u>	<u>1960</u>	<u>1959</u>	<u>1960</u>
Pittville	nr	0.82	0.0123	0.0125
Arvin	0.69	0.69	0.0099	0.0095

The close similarity between the coefficients determined from the measured periods as compared with the total seasonal period of record, including estimated periods, indicates that the

measured periods are not biased, and the seasonal coefficients appear to be reasonable. Curves of seasonal accumulated evapotranspiration versus evaporation are shown on Plate 5, Figures C and D. As noted previously, each curve on Plate 5 is plotted for an individual year, with separate zero lines for indication of evapotranspiration. Evaporation from pan and atmometers was plotted, using the date of June 30 as the common point on all curves.

The pan and atmometer coefficients derived after combining the two years of record at the Pittville AA plot are shown in Table 7, and are compared with coefficients derived in the same manner at the Arvin CC plot. For purposes of comparison, average coefficients were determined not only for the period of record, but also for the growing season, as shown in Bulletin No. 2.

By any method of determining seasonal coefficients, the Pittville pan coefficient is approximately 17 percent higher than the Arvin coefficient, and the Pittville atmometer coefficient is approximately 27 percent higher than the Arvin coefficient. Whether the difference is due primarily to basic climatic differences between the two areas, which affect different plant and evaporation response, or due to experimental error, is not known at this time.

Cotton Coefficients

Pan and atmometer coefficients for cotton for each period of measurement during 1959 and 1960 are shown in Figures J and K of Plate 4. Also shown are estimates of the percent of ground cover, available moisture, and other factors affecting plant growth and water use. There is a rather close agreement between the two years

TABLE 7
PAN AND ATMOMETER COEFFICIENTS FOR ALFALEA

Month	Pan Coefficients				Atmometer Coefficients			
	Tulare Lake Basin	Sacramento River Basin	Tulare Lake Basin	Sacramento River Basin	Valley Floor	Mountain Valleys	Valley Floor	Mountain Valleys
	(Arvin (CC))	(Pittville (AA))	(Arvin (CC))	(Pittville (AA))	(Arvin (CC))	(Pittville (AA))	(Arvin (CC))	(Pittville (AA))
	1959 & 1960	1960 only	1959 & 1960	1960 only	1959 & 1960	1959 & 1960	1959 & 1960	1959 & 1960
	No. Days	No. Days	No. Days	No. Days	No. Days	No. Days	No. Days	No. Days
	of Record	ET/Ep*	of Record	ET/Ep	of Record	ET/Ep**	of Record	ET/Ep-w
January	--	--	--	--	--	--	--	--
February	--	--	--	--	--	--	--	--
March	18	0.53	21	0.63	18	0.0065	19	0.0108
April	30	0.64	30	0.61	30	0.0095	60	0.0104
May	51	0.52	31	0.96	51	0.0088	62	0.0140
June	60	0.71	30	0.64	60	0.0109	62	0.0127
July	62	0.64	31	0.81	62	0.0101	60	0.0129
August	62	0.76	31	0.97	62	0.0112	62	0.0129
September	60	0.78	30	0.87	60	0.0098	60	0.0129
October	62	0.68	31	0.96	62	0.0074	60	0.0129
November	47	0.88	8	0.89	17	0.0046	--	--
December	31	1.11	--	--	--	--	--	--
Average								
Coefficient								
for Growing								
Season ¹	295	0.68 ^a /	153	0.81 ^b /	387	0.0099 ^a /	263	0.0121 ^b /
Period of								
Record	483	0.69	243	0.82	422	0.0097	--	--

¹/ For growing season periods used in Bulletin No. 2.

^a/ April-October

^b/ May-September

* ET/Ep = Pan Coefficient, ET/Ep-w = Atmometer Coefficient

in regard to the general pattern of plant growth and the relationships of the coefficient with the various factors affecting water use. The soil moisture observations are believed to be of reliable quality, particularly for the 1960 data, where a dry soil zone was maintained at depth below the root zone, assuring that no deep percolation of irrigation water occurred.

Coefficients for individual period of measurements show a pattern of progressive increase from the low early season value to a peak in July, and then a progressive decrease to the year's end. The differences in coefficients during the early season emphasized the direct relationship between the evapotranspiration and percent of ground cover. The decreasing pattern of coefficients after July reflects the integrated effect of decreasing ground cover, physiological aging of the plants, and availability of soil moisture.

It is of interest that, although ground cover on these plots reached 80 and 95 percent, the maximum coefficients were reached at a ground cover of about 60 percent. This corresponds in time to the boll setting. It is believed that physiological factors may have had an influence on the transpiration rate at this stage of plant development. Physiological factors are believed to have caused similar effects in other crops. With small grains, for example, peak water use rates are reported to occur at the heading stage.

Late-season use of water by cotton is dependent to some extent upon the amount of moisture available prior to natural or

induced defoliation. The plants will generally use all available moisture within the root zone. The amount of use is a function of the amount of moisture available. This is to say that the availability of soil moisture is often the limiting factor in the late-season evapotranspiration. This also may account, in part, for the August-September coefficients being lower than the July coefficient.

Early- or late-season precipitation, although a part of evapotranspiration and reflected in the pan and atmometer coefficients, is, quite often, not a beneficial source of moisture to the plants. Early-season precipitation is evaporated from the soil surface with little gainful effect upon plant growth. Late-season precipitation is either evaporated from the soil or vegetative surface, and/or transpired by the plant without contributing substantially to the plant cultural requirements. Thus, pan and atmometer coefficients for early and late season must be applied with caution and only after a thorough evaluation of rainfall amount, frequency and pattern, as well as knowledge of the late-season availability of soil moisture.

Based on the information summarized in Table 5, monthly pan and atmometer coefficients for the two years of record have been determined, and are shown on Figures A and B on Plate 5. There is, in general, rather close agreement between the monthly pan or atmometer coefficients for both 1959 and 1960. There are also several indications that evapotranspiration for cotton sometimes exceeds evaporation from pans. The July pan coefficients for 1959 and 1960 were respectively 1.07 and 1.08, which indicates that evapotranspiration exceeds evaporation from the free-water

surface. It is believed that the crop surface roughness may, through greater air mixing, be one of the influencing factors.

Average monthly pan and atmometer coefficients for cotton for the two years of record are presented in Table 8. For purposes of comparing with Bulletin 2 estimates, an average coefficient for the Tulare Lake Basin Valley Floor Hydrographic Units was determined for the growing season used in Bulletin 2. For the period from May through October, the active growing season, the average pan coefficient is 0.68, and the atmometer coefficient is 0.0098. The monthly coefficients for the period from June through September are considered to be primarily the effect of climatic evaporative demand and crop conditions, and are not subject to the influence of early-or late-season nonbeneficial uses.

Application of Coefficients and Evaporation Data to Estimation of Evapotranspiration

Using the average pan or atmometer evaporation observed in each area, as shown in Tables 2 and 3 in Chapter II, and applying the appropriate pan or atmometer coefficients as described in Tables 6, 7, and 8, estimates of monthly consumptive use values were made for several crops. These monthly estimates are summarized in Table 9, and are compared with values utilized in Bulletin 2, "Water Utilization and Requirements in California," published by the department in 1955. To make the comparison with Bulletin 2 values valid, the growing seasons used in Bulletin 2 were used in all calculations for Tables 6 through 9. In general, the estimates based upon the pan and atmometer coefficients are approximately equal to or greater than the Bulletin 2 values. This is also true where measured values of consumptive use are available. This, in

TABLE 8
PAN AND ATMOMETER COEFFICIENTS FOR COTTON

Month	Pan Coefficients		Atmometer Coefficients	
	Tulare Lake Basin Valley Floor		Tulare Lake Basin Valley Floor	
	(Arvin (CD) 1959		(Arvin (CD) 1959	
	Arvin (CF) 1960)		Arvin (CF) 1960)	
	No. Days		No. Days	
	of Record	ET/Ep*	of Record	ET/Eb-w*
January	--	--	--	--
February	--	--	--	--
March	8	0.75	--	--
April	30	0.14	30	0.0019
May	62	0.11	62	0.0018
June	60	0.67	60	0.0103
July	62	1.08	62	0.0170
August	62	0.99	62	0.0147
September	60	0.84	60	0.0106
October	62	0.46	62	0.0051
November	60	0.26	60	0.0023
December	62	0.15	--	--
Average Coefficient for Growing Season ^{1/}	398	0.68 ^{a/}	398	0.0098 ^{a/}
Period of Record	--	--	--	--

^{1/} For growing season periods used in Bulletin No. 2, Tulare Lake Basin Valley Floor hydrographic units.

^{a/} April-October

* ET/Ep = Pan Coefficient, ET/Eb-w = Atmometer Coefficient

COMPARISON OF SEASONAL CONSUMPTIVE USE
OF ALFALFA, PASTURE, AND COTTON
BASED ON BULLETIN NO. 2 GROWING SEASON

(in inches)

Area	Alfalfa		Pasture-Grass		Cotton						
	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :	Based on: Bull. Measure- : Pan Data: #2 : ment : : Data :					
Klamath-Trinity Mountain Valleys	34.77	32.66	27.41	--	40.56	38.98	27.41	--	--	--	--
Sacramento River Basin Mountain Valleys	31.71	31.93	25.15	35.11	37.00	38.11	25.15	37.79	--	--	--
Sacramento River Basin Poothills	28.44*	27.94	29.65	--	29.69*	30.66*	29.65	--	--	--	--
	35.13**	33.64	29.65	--	40.98**	40.15**	29.65	--	--	--	--
Sacramento River Basin Valley Floor	37.50	34.40	36.48	--	39.70	39.96	36.48	45.11	--	--	--
San Joaquin River Basin Valley Floor	38.79	34.61	35.84	--	41.08	40.19	35.84	--	36.49	31.28	23.43
Tulare Lake Basin Valley Floor	35.35	34.45	37.14	35.87	37.42	40.03	37.14	--	33.43	32.24	28.78
Lesser-Alpine Mountain Valleys	35.98	32.00	27.24	--	41.98	38.20	27.24	--	--	--	--

* Calculated using valley coefficient.

** Calculated using mountain coefficient.

itself, does not prove that the estimates based upon pan and atmometer coefficients are more accurate. Additional supporting data shall be required to confirm this possibility.

Examination of the data in Table 9 indicates that estimates of consumptive use can be made with equal confidence, on the basis of either pan or atmometer data. It should be emphasized also that the consumptive use values must be determined for the actual period of active plant growth. The actual growing season for most crops in the various areas of the State still remains to be determined. Furthermore, a careful analysis of precipitation pattern, frequency, and amounts must be made for both growing and nongrowing seasons, to determine the effectiveness of this moisture source toward meeting the water demand of the various crops.

CHAPTER V. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents a concise summary of the vegetative water use studies, the conclusions drawn therefrom, and recommendations with regard to the future lines of study.

Summary

Precise knowledge of the total seasonal as well as the distribution pattern of water use throughout the year is basic to the planning, design, and operation of comprehensive water development projects. In developing this essential knowledge, the department has been engaged in studies directed toward determination of evapotranspiration. During the period from 1954 to 1960, these studies were limited to certain geographic regions of northern and central California.

Accurate measurement of evapotranspiration is so complex and costly that practical considerations limit collection of these data to relatively few locations. Recent research work by various groups throughout the world has pointed out certain fundamental relationships between the evapotranspiration process and climatic factors. Transpiring crops respond to the same energy sources as evaporation devices. The response of crops, however, is modified by physical and physiological characteristics. Under any given climatic condition, factors such as availability of soil moisture, percent of vegetative ground cover, and physiological development control the rate of evapotranspiration.

The approach taken in these studies has been to study at a few locations the relationship between measured evapotranspiration, under specified crop conditions, and certain climatic indices. Concurrently with the measurement and correlation of evapotranspiration and climatic factors, a network of agroclimatic stations was established and observed throughout the several major inland agricultural areas in northern and central California. Having determined evaporation at these stations, estimates of evapotranspiration can be extrapolated into these areas by using the relationship between evapotranspiration and evaporation data measured at the key evapotranspiration stations.

In the early years of these studies, available knowledge on climatic station environmental requirements was very meager. However, as data were collected and analyzed, the importance of certain environmental effects became apparent. Stations were relocated to sites where they were surrounded by an extensive area of vigorous, low-growing vegetation at full ground cover. Large, well-managed pastures best meet these requirements. At such sites, the confounding effects of micro-environment differences are minimized.

The techniques used for the determination of evapotranspiration were the best available methods for the task, at the time they were employed. However, as the study progressed, techniques were modified to take advantage of new and better tools as they became available. The initial soil moisture measurements to determine evapotranspiration were made by the

gravimetric technique. The development and refinement of the neutron scattering technique offered promise of a far superior method of making soil moisture determinations. For this reason, this new equipment was adopted shortly after it became commercially available.

Small evapotranspirometer tanks of various designs were installed and used where high-water table conditions prohibited the use of soil moisture depletion techniques, and were later installed on sites where no high water tables existed. The success of these devices has encouraged the extension of this method to other close growing crops.

Estimates of evapotranspiration were made for all areas studied, using pan and atmometer coefficients and evaporation data collected as part of the agroclimatic program. These estimates were compared to Bulletin 2 consumptive use values, using the Bulletin 2 growing seasons. In many cases, the estimates obtained by using the evaporation correlation technique were higher than were the Bulletin 2 values.

Data collected at the evapotranspiration field plots indicate that the actual periods of active growth are considerably longer than those assumed in the determination of Bulletin 2 values. On a yearly basis, the estimates shown in this report may show even a greater variance with Bulletin 2 values.

As the estimated values presented in this report are based upon only two years of record, they should be used with considerable caution. However, the evaporation correlation

technique appears to promise a reasonable means of estimating, with precision heretofore unknown, evapotranspiration rates for crops in the various geographic areas of California.

Conclusions

1. Correlation of evaporation with evapotranspiration appears to promise a reasonable means of estimating evapotranspiration within the various agricultural area of the State.

2. Reasonable estimates may be obtained by using either pan, or atmometer coefficients.

3. Pan and atmometer coefficients are strongly influenced by percent of ground cover, particularly for ground cover percentage less than (60%) sixty percent.

4. Estimated values presented in this report are based upon only two years of record, and so should be used with considerable judgment.

5. On the basis of the agroclimatic data collected, no definite segregation of the State into areas of uniform evaporation is possible at present. Inland areas appear to have more uniform evaporation rates than expected, although effects of microenvironment cause large differences of evaporation between individual measurement sites.

6. It may be found that the length of growing season is the most important factor affecting seasonal evapotranspiration in inland areas.

Recommendations

On the basis of the collection and analysis of the data on vegetative water use, as presented in this report, and on the conclusions drawn therefrom, it is recommended that:

1. The evapotranspiration studies at the present sites be continued until sufficient data can be collected to provide reasonable estimates of evapotranspiration under the range of climatic conditions which can occur at these locations.

2. Additional sites for evapotranspiration measurements be established in locations having different climatic conditions than those now being measured to determine variability of evapotranspiration coefficients (i.e., Delta area, coastal areas, and desert areas).

3. The scope of the present program be expanded to include measurements of applied water under different irrigation practices and lengths of growing seasons for major crops within the various agricultural zones of the State. This would provide the basic information needed to determine irrigation efficiencies, drainage requirements, and, with the unit evapotranspiration values, to determine total irrigation water requirements.



APPENDIX A

Supplemental Agroclimatic and Evapotranspiration Data

TABLE OF CONTENTS

<u>Number</u>		<u>Page</u>
A-1	Agroclimatic Stations, Location and General Information	79
A-2	Monthly Evaporation From Standard U. S. Weather Bureau Evaporation Pans	85
A-3	Monthly Evaporation Differences Between Livingston Spherical Black and White Atmometers .	90
A-4	Location of Evapotranspiration Measuring Stations	98
A-5	General Information Relative to Evapotranspiration Measuring Stations	100
A-6	Neutron Probe Measurements of Evapotranspiration and Related Data for Several Irrigated Crops, 1959 and 1960	107
A-7	Evapotranspirometer Measurements and Related Data for High-Water Table Pasture and Irrigated Ryegrass	113

TABLE A-1

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MD&M	County	Location	Description	Eleva- tion, : in feet	Ob- server ² :	Evaporation equipment	Irriga- tion : Pan:Atmometers : method
KLAMATH, TRINITY MOUNTAIN VALLEYS								
NORTH COASTAL								
Pasture								
Montague 3NE	T45N R6W	Siskiyou	3 mi. NE of Montague		2600	DWR	x	Surface
Alfalfa								
Callahan Towne Ranch	T41N R9W	Siskiyou	5 mi. N of Callahan		2891	DWR	-	Surface
Gazelle 3NNW	T43N R6W	Siskiyou	3 mi. NNW of Gazelle		2720	DWR	-	Sprinkler
Grenada 6E	T44N R5W	Siskiyou	6 mi. E of Grenada		2640	DWR	-	Surface
Dryland								
Fort Jones R. S.	T43N R9W	Siskiyou	Town of Fort Jones		2720	USFS	x	--
Gazelle 1NNE	T43N R6W	Siskiyou	1 mi. NNE of Gazelle		2720	DWR	-	--
Hayfork R. S.	T31N R12W	Trinity	1 mi. E of Hayfork		2346	USFS	-	--
Madoel F. S.	T46N R4W	Siskiyou	Town of Madoel		2718	CDP	-	--
Yreka 1NE	T45N R7W	Siskiyou	1 mi. NE of Yreka		2625	DWR	x	--
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS								
CENTRAL VALLEY								
Pasture								
Alturas Dorris Ranch	T42N R13E	Modoc	2 mi. SE of Alturas		4450	DWR	x	Surface
Fall River Mills 4NW	T37N R4E	Shasta	4 mi. NW of Fall River Mills		3500	DWR	x	Sprinkler
Glenburn DWR	T37N R4E	Shasta	1/2 mi. SSE of Glenburn		3500	DWR	x	Surface
Hat Creek 3N	T34N R4E	Shasta	3 mi. N of Hat Creek		3350	DWR	-	Surface
Likely Williams Ranch	T40N, R13E	Modoc	3 mi. N of Likely		4400	DWR	-	Surface
Lookout Hunt	T39N R7E	Lassen	3 mi. S of Lookout		4200	DWR	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDSM	County	Location	Description	Eleva- tion, in feet	Ob- servations	Evaporation equipment	Irriga- tion method
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)								
Alfalfa								
Bieber 4E	T38N R9E	Lassen	4 mi. E of Bieber		4200	DMR	-	Sprinkler
Canby 11SW	T41N R8E	Modoc	11 mi. SE of Canby		4500	DMR	x	Surface
Hat Creek 3SE	T33N R8E	Shasta	3 mi. SE of Hat Creek		3660	DMR	x	Surface
Lookout 1S	T39N R7E	Lassen	1 mi. S of Lookout		4200	DMR	x	Surface
McArthur 2E	T37N R5E	Shasta	2 mi. E of McArthur		3325	DMR	x	Surface
Pittville 1S	T37N R5E	Shasta	1 mi. S of Pittville		3300	DMR	x	Sprinkler
Dryland								
Adin Harper	T39N R9E	Modoc	2 mi. NE of Adin		4200	DMR	x	--
Alturas Park Avenue	T42N R13E	Modoc	Town of Alturas		4440	DMR	-	--
Bieber S.C.S.	T38N R7E	Lassen	Town of Bieber		4169	USDA	-	--
Big Sage Reservoir	T43N R11E	Modoc	South side of reservoir		4400	DMR	x	--
Canby 0NW	T42N R9E	Modoc	1 mi. W of Canby		4310	DMR	-	--
Canby R. S.	T42N R10E	Modoc	Town of Canby		4310	USFS	-	--
Davis Creek 4WNW	T45N R13E	Modoc	4 mi. NW of Davis Creek		5000	DMR	-	--
Fall River Mills Intake	T37N R8E	Shasta	1 mi. NW of Fall River Mills		3325	FOAE	-	--
Fall River Mills R.S.	T37N R8E	Shasta	Town of Fall River Mills		3325	USFS	-	--
Likely 4E	T40N R13E	Modoc	4 mi. N of Likely		4400	DMR	-	--
Loyalton 5W	T22N R15E	Sierra	5 mi. W of Loyalton		4880	DMR	-	--
Loyalton 7E	T22N R15E	Plumas	7 mi. W of Loyalton		4880	DMR	-	--
Mt. Shasta City N.B.	T32N R14E	Siakiyou	Town of Mt. Shasta		3554	USFS	-	--
Quincy R.S.	T24N R9E	Plumas	Town of Quincy		3442	USFS	-	--
West Valley Reservoir	T39N R14E	Modoc	7 mi. E of Likely		5500	DMR	x	--
Miscellaneous								
Adin R.S.	T39N R9E	Modoc	Town of Adin		4200	USFS	-	--

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	NDBM	County	Location	Description	Eleva- tion : in feet	Ob- serve: Pan:Atmometers	Evapora- tion : equipment	Irriga- tion : method
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN POOTHILLS								
Pasture								
Auburn Mt. Vernon	TL3N	R7E	25E1	Placer				
Gold Hill Doty Flat	TL2N	R7E	12D1	Placer				
Loma Rica	TL7N	R5E	34J1	Yuba				
Penn Valley	TL6N	R7E	28H1	Nevada				
Dryland								
Bella Vista 4NE	T33N	R3W	27E1	Shasta				
Browns Valley 3NE	TL6N	R5E	12H1	Yuba				
Neville	T22N	R6W	2E1	Glenn				
SACRAMENTO RIVER BASIN VALLEY FLOOR								
Pasture								
Anderson 4E	T30N	R3W	17F1	Shasta				
Corning 3NE	T24N	R3W	12L1	Tehama				
Davis Campbell #1	T3N	R2E	17K1	Yolo				
Elk Grove 4NW	T7N	R5E	28E1	Sacramento				
Lincoln Vineyard	TL3N	R6E	26G1	Placer				
Palemo 3SW	TL8N	R4E	19D1	Butte				
Red Bluff Cone Ranch	T27N	R2W	30D1	Tehama				
Yuba City 9W	TL5N	R2E	21R1	Sutter				
Alfalfa								
Anderson 2E	T30N	R3W	18G1	Shasta				
Anderson 3E	T30N	R3W	17M1	Shasta				
Arbuckle 1S	TL3N	R2W	11E1	Colusa				
Corning Jobe	T24N	R3W	20D1	Tehama				
SACRAMENTO RIVER BASIN VALLEY FLOOR								
Pasture								
Anderson 4E	T30N	R3W	17F1	Shasta				
Corning 3NE	T24N	R3W	12L1	Tehama				
Davis Campbell #1	T3N	R2E	17K1	Yolo				
Elk Grove 4NW	T7N	R5E	28E1	Sacramento				
Lincoln Vineyard	TL3N	R6E	26G1	Placer				
Palemo 3SW	TL8N	R4E	19D1	Butte				
Red Bluff Cone Ranch	T27N	R2W	30D1	Tehama				
Yuba City 9W	TL5N	R2E	21R1	Sutter				
Alfalfa								
Anderson 2E	T30N	R3W	18G1	Shasta				
Anderson 3E	T30N	R3W	17M1	Shasta				
Arbuckle 1S	TL3N	R2W	11E1	Colusa				
Corning Jobe	T24N	R3W	20D1	Tehama				

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MOBAM	County	Location	Description	Elevation, in feet	Ob- server ^a	Evaporation equipment	Irriga- tion method
<u>CENTRAL VALLEY (continued)</u>								
<u>SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)</u>								
<u>Alfalfa (continued)</u>								
Hamilton City	T22N R1E 20N1	Glenn		1 mi. N of Hamilton City	150	DMR	-	Surface
Red Bluff 3E	T27N R3W 23J1	Tehama		3 mi. E of Red Bluff	270	DMR	x	Surface
Rocklin Igarashi	T11N R7E 29C1	Placer		1 mi. SE of Rocklin	310	DMR	x	Sprinkler
Vina Beck	T24N R2W 23Q1	Tehama		2 mi. S of Vina	188	DMR	-	Surface
Yuba City	T15N R2E 22D1	Sutter		9 mi. W of Yuba City	46	DMR	-	Surface
<u>Dryland</u>								
Davis Campbell #2	T6N R2E 17K1	Yolo		Univ. of Calif. farm	50	DMR	-	--
Mills Orchard	T22N R3W 26F1	Glenn		2 mi. W of Hamilton City	175	DMR	-	--
Oroville Agric. Com.	T19N R4E 6M1	Butte		1 mi. NW of Oroville	270	DMR	x	--
Redding 6SE	T31N R4W 15Q1	Shasta		6 mi. SE of Redding	515	DMR	-	--
Redding Stayer	T31N R4W 15K1	Shasta		6 mi. SE of Redding	510	DMR	x	--
Sacramento Refuge	T18N R3W 10F1	Glenn		6 mi. S of Willows	96	DMR	x	--
<u>Miscellaneous</u>								
Corning 3NW	T24N R3W 8K1	Tehama		3 mi. NW of Corning	307	DMR	-	--
Live Oak 3SE	T16N R3E 10R1	Yuba		3 mi. SE of Live Oak	70	DMR	-	Surface
Pennington 3NW	T17N R1E 15Q1	Butte		3 mi. NW of Pennington	60	DMR	x	Marsh
Redding A.P.	T31N R4W 27K1	Shasta		7 mi. SE of Redding	500	CAA	-	Sprinkler
Redding R.S.	T31N R5W 10D1	Shasta		Town of Redding	500	CDF	-	Sprinkler
Richvale 1E	T19N R2E 23D1	Butte		1 mi. E of Richvale	105	DMR	-	--
<u>SAN JOAQUIN RIVER BASIN VALLEY FLOOR</u>								
<u>Pasture</u>								
Berenda 2W	T10S R17E 8P1	Madera		2 mi. N of Berenda	270	DMR	x	Surface
El Solyo Ranch	T4S R7E 5J1	Stanislaus		4 mi. SE of Vernalle	35	DMR	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDBAM	County	Location	Description	Eleva- tion, in feet	Ob- serve/s	Evaporation equipment	Irriga- tion method
SAN JOAQUIN RIVER BASIN VALLEY FLOOR (continued)								
CENTRAL VALLEY (continued)								
Pasture (continued)								
Lodi 35W	T3N R6E 27B1	San Joaquin	3 mi. SW of Lodi		29	DWR	x	Surface
Merced 5SE	T8S R15E 6E1	Merced	5 mi. SE of Merced		198	DWR	x	Surface
Newman 1SE	T7S R9E 29B1	Merced	1 mi. SE of Newman		87	DWR	x	Surface
Stockton 9S	T1S R7E 19H1	San Joaquin	9 mi. S of Stockton		27	DWR	x	Surface
Thornett 2S	T4W R5E 15H1	San Joaquin	2 mi. S of Thornett		7	DWR	x	Surface
Alfalfa								
Atwater 1N	T7S R12E 35P1	Merced	1 mi. N of Atwater		150	DWR	-	Sprinkler
Ceres 3E	T4S R10E 7J1	Stanislaus	3 mi. E of Ceres		104	DWR	x	Surface
Lodi 3S	T3N R7E 30Q1	San Joaquin	3 mi. S of Lodi		41	USDA	x	Surface
Los Banos 3S	T10S R10E 33P1	Merced	3 mi. S of Los Banos		161	USDA	-	Surface
Los Banos 8SE	T11S R11E 19K1	Merced	8 mi. SE of Los Banos		140	USDA	-	Surface
Stockton 8S	T1S R7E 39E1	San Joaquin	8 mi. S of Stockton		25	DWR	-	Surface
Vernalis 3SE	T4S R7E 5J1	Stanislaus	3 mi. SE of Vernalis		69	DWR	x	Surface
Miscellaneous								
Los Banos Equipment Yard	T10S R10E 32K1	Merced	6 mi. SW of Los Banos		160	USBR	x	--
Twitchell Island	T3N R3E 16K1	Sacramento	6 mi. SE of Rio Vista		10	DWR	-	--
TULARE LAKE BASIN VALLEY FLOOR								
Pasture								
Arvin Frick	T31S R29E 16F1	Kern	4 mi. NW of Arvin		437	DWR	x	Surface
Kerman 2ESE	T14S R18E 17H1	Fresno	2 mi. ESE of Kerman		225	DWR	x	Surface
Kingsburg 5S #2	T17S R22E 16H1	Kings	5 mi. SW of Kingsburg		277	DWR	x	Surface
Alfalfa								
Arvin Jewett #1	T31S R29E 16H1	Kern	2 1/2 mi. NW of Arvin		448	DWR	x	Surface
Arvin Jewett #2	T31S R29E 16G1	Kern	2 1/2 mi. NW of Arvin		440	DWR	x	Surface
Fresno Kearney Park	T14S R19E 19K1	Fresno	2 mi. SW of Kearney Park		238	DWR	-	Surface
Kingsburg 5S #1	T17S R22# 15H1	Kings	5 mi. SW of Kingsburg		276	DWR	x	Surface
Mendota Murietta Ranch	R15S R14E 4N1	Fresno	6 mi. SW of Mendota		253	MFC	-	Surface
Shafter 2NW	T27S R25E 32J1	Kern	2 mi. NW of Shafter		353	DWR	x	Surface

TABLE A-1 (continued)

AGROCLIMATIC STATIONS,
LOCATION AND GENERAL INFORMATION

Area, environment, and station name	MDRM	County	Location	Description	Eleva- tion, : : in feet	Ob- serv- ers	Evapora- tion : : Pan:Atmometers	Irriga- tion : : method
<u>CENTRAL VALLEY (continued)</u>								
<u>TULARE LAKE BASIN VALLEY FLOOR (continued)</u>								
<u>Dryland</u>								
Panoche Junction	T16S	RL4E	16P1	Fresno	15 mi. SSW of Mendota	500	DWR	x x --
<u>LASSEN-ALPINE MOUNTAIN VALLEYS</u>								
<u>LAHONTAN</u>								
<u>Pasture</u>								
Cedarville 2E	T42N	RL6E	10B1	Modoc	2 mi. E of Cedarville	4670	DWR	x x Subsurface
Coleville 2W	T8N	R22E	3K1	Mono	2 mi. W of Coleville	5120	DWR	x x Subsurface
Standish 4NW	T29N	RL3E	11N1	Lassen	4 mi. NW of Standish	4100	DWR	x x Subsurface
<u>Alfalfa</u>								
Cedarville 1E	T42N	RL6E	4P1	Modoc	1 mi. E of Cedarville	4670	DWR	- x Sprinkler
Standish 1NW	T29N	RL4E	18R1	Lassen	1 mi. NW of Standish	4060	DWR	- x Surface
<u>Dryland</u>								
Bridgeport DWR	T5N	R25E	33D1	Mono	Town of Bridgeport	6465	DWR	- x --
Eagle Lake Stone Ranch	T32N	RL2E	5N1	Shasta	22 mi. NW of Susanville	5120	DWR	- x --
Cedarville Chevron	T42N	RL6E	5Q1	Modoc	Town of Cedarville	4670	DWR	- x --
Leavitt Lake	T29N	RL3E	16N1	Lassen	10 mi. SE of Susanville	4112	PC	- x --
Madeline 3W	T37N	RL3E	19Q1	Lassen	3 mi. SW of Madeline	5400	DRG	- x --
Terro	T35N	RL3E	25N1	Lassen	Town of Terro	5290	DWR	- x --
Woodfords	T11W	R20E	35D1	Alpine	Town of Woodfords	5526	DWR	- x --
<u>Miscellaneous</u>								
Taboe	T15N	RL7E	7R1	Placer	1 mi. S of Truckee Dam	5818	DWR	- x --

s/ CAA - Civil Aeronautics Administration
CDF - California Division of Forestry
CGR - City of Santa Rosa
DFG - California Department of Fish and Game
DWR - California Department of Water Resources
MFC - Murietta Farms Company
PC - Private Cooperator
P&E - Pacific Gas and Electric Company
UC - University of California
USBR - United States Bureau of Reclamation
USDA - United States Department of Agriculture
USFS - United States Forestry Service

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

-85-

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS

(in inches)

Area, environment, and station name	Year of: record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	May-Sept.
CENTRAL VALLEY (continued)															
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)															
Dryland															
Adin Harper	1959	1.25	3.44	6.22	5.77	10.10	12.40	10.25	7.77	4.89	2.54			46.29	
Adin Harper	1960	0.91													
Big Sage Reservoir	1959	1.05	2.62	6.29	5.69	9.19	12.54	10.40	6.63	3.44	1.92			44.80	
Big Sage Reservoir	1960	1.09													
Davis Creek 4.1NW	1959	1.83	3.46	6.24		9.43	13.32	11.21	7.10	4.27	1.93			49.38	
Davis Creek 4.1NW	1960	1.02	2.46	5.13	7.12	10.95	12.10	10.93	8.23	4.55	1.05	0.34			
West Valley Reservoir	1953														
West Valley Reservoir	1959			5.98	5.24	10.22	12.30	11.43	7.27	3.15	3.00			46.51	
West Valley Reservoir	Mean	1.20	2.99	5.98	5.95	10.02	12.03	11.06	7.41	4.60	2.09				
SACRAMENTO RIVER BASIN FOOTHILLS															
Pasture															
Gold Hill Doty Flat	1953														
Gold Hill Doty Flat	1959	1.49	2.3	4.25	1.80	9.3	11.32	3.91	6.31	5.98	2.52	1.02		43.21	
Gold Hill Doty Flat	1960	1.33	2.72	3.29	5.9	6.0	9.9	10.70	3.91	2.03	2.01	2.01	1.07	42.84	
Loma Rica	1950														
Penn Valley	1953														
Penn Valley	1959	1.36	3.54	5.25	3.33	9.02	10.30	9.35	4.43	4.1	1.77	1.51	1.60	41.51	
Penn Valley	1960	1.39	1.70	2.32	4.32	5.35	7.37	9.45	3.98	5.00	4.21	1.97	1.12	38.48	
Penn Valley	Mean	1.52	2.29	3.56	5.19	6.30	9.15	10.66	9.27	6.44	5.00	2.20	1.52		
Dryland															
Rolla Vista 4NE	1959			5.00	0.02	9.33	12.61	1.4	12.50	9.90	7.57	5.27	4.22	61.43	
Rolla Vista 4NE	1960			4.23	5.30	7.37	14.31	15.93	12.78	12.78	2.84	3.43	3.92	65.25	
Brown Valley 3NE	1953														
Brown Valley 3NE	1959	1.38	2.32	4.54	6.94	8.29	12.77	14.35	12.11	9.09	5.94	2.81	2.17		
Brown Valley 3NE	1960	1.47	2.53	3.67	5.1	7.94	12.11	13.40	12.02	8.99	3.14	2.21	2.21	57.31	
Newville	1959			4.84	7.72	10.65	13.99	15.16	12.42	10.73	8.03	5.46	3.23	62.95	
Newville	1960	1.42	2.89	4.29	5.50	7.82	14.34	14.70	13.00	10.44	7.73	2.97	1.89	60.30	
Newville	Mean	1.42	2.75	4.60	6.52	8.69	13.36	15.04	12.46	10.27	7.42	3.89	2.94		

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS

(in inches)

Area, environment, and station name	:Year of: : record	Months												: May-Sept.	
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.	: total	
CENTRAL VALLEY (continued)															
Pasture															
Anderson 4E	1958	1.99	4.19	5.61	7.26	8.92	9.54	8.09	6.23	4.01	1.65	2.76	1.58	40.06	
Anderson 4E	1959	0.91	2.31	3.77	4.68	6.49	9.31	8.70	6.15	3.91	1.65	1.32	1.32	40.23	
Anderson 4E	1960	2.28	2.69	4.61	5.35	7.78	12.57	12.73	11.41	7.55	3.90	1.93	1.93	53.51	
Corning 3NE	1960	1.34	2.32	2.96	4.94	6.90	9.15	9.35	7.56	6.88	5.31	2.86	2.15	38.65	
Elk Grove 4NW	1958														
Lincoln Vineyard	1959	1.72	2.62	5.12	6.35	8.58	10.71	11.80	9.77	6.74	6.06	3.50	2.41	47.60	
Lincoln Vineyard	1960	1.99	2.70	4.14	6.05	7.58	11.62	12.97	12.16	7.21	6.12	2.66	1.75	51.54	
Lincoln Vineyard	1960	1.80	2.49	3.43	5.49	7.22	9.72	10.31	9.43	6.62	5.27	2.39	1.55	43.30	
Palermo 3SW	1959	1.88	2.18	5.07	6.23	6.91	10.10	10.81	8.72	8.32	5.54	3.34	2.23	44.86	
Red Bluff Cone Ranch	1959	1.43	2.76	3.68	4.95	6.86	10.62	11.37	8.36	7.05	5.70	2.00	1.81	44.26	
Red Bluff Cone Ranch	1960	1.50	2.88	3.44	5.20	7.06	10.08	8.84	8.31	5.91	5.60	2.45	1.59	40.20	
Yuba City 9W	Mean	1.65	2.49	4.04	5.48	7.26	10.28	10.73	9.18	6.87	5.34	2.58	1.74		
Alfalfa															
Red Bluff 3E	1958							7.06	8.48	6.49	5.10	2.11			
Dryland															
Oroville Agriculture Commission	1958														
Oroville Agriculture Commission	1959	3.00	5.41	7.48	9.87	13.41	14.72	12.32	9.84	7.86	3.66	8.43		60.16	
Redding Stayer	1958														
Redding Stayer	1959	1.24	2.43	5.80	7.94	10.18	13.79	15.82	12.94	9.94	6.77	4.51	2.56	62.67	
Redding Stayer	1960	1.42	2.67	4.21	5.46	8.16	14.93	15.95	14.38	10.54	7.26	1.91	1.46	63.96	
Sacramento Refuge	1957														
Sacramento Refuge	1958														
Sacramento Refuge	1959	1.35	1.82	5.34	7.52	9.80	14.25	13.24	10.29	8.74	6.72	3.83	2.15	56.32	
Sacramento Refuge	1960	1.04	2.50	3.63	5.15	8.34	12.69	12.83	11.76	8.55	6.48	2.59	1.44	54.17	
Sacramento Refuge	Mean	1.26	2.48	4.88	6.52	8.95	13.25	14.03	11.87	9.45	7.24	3.19	1.90		
Miscellaneous															
Pennington 3NW	1960							5.82	3.62	3.91	1.90	1.22			

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Area, environment, and station name	: Year of: : record	Months												: May-Sept. : total
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.	
CENTRAL VALLEY (continued)														
SAN JOAQUIN RIVER BASIN VALLEY FLOOR														
Pasture														
Herenda 2N	1960					9.06	10.31	10.74	9.49	6.43	4.46	1.43	0.74	46.03
El Soloyo Ranch	1959				5.97	9.32	11.12	10.66	9.01	7.17	5.47	2.53	2.10	47.48
El Soloyo Ranch	1960	1.67	2.76	4.14	6.17	9.02	10.34	9.15	8.55	6.43	4.94	1.79	1.09	43.49
Lodi 35A	1959		1.84	4.50	5.99	8.21	10.10	9.84	8.22	6.41	4.98	2.33		42.78
Merced 53E	1959		1.96	4.49	6.03	9.36	12.03	13.08	10.63	7.93	5.53	2.63	1.94	53.08
Merced 53E	1960	1.76	2.02	4.22	6.10	9.59	11.29	12.12	10.65	8.05	4.95	1.69	0.98	51.70
Newman 13E	1960					10.15	9.25	8.77	6.60	6.24	4.95	1.98	0.95	45.98
Stockton 93	1959		1.84	2.43	4.34	6.33	9.16	11.05	10.70	8.70	6.37	2.43	1.55	44.32
Stockton 98	1960				6.40	3.56	10.32	10.42	8.84	6.13	5.66	2.07	1.69	
Thornton 23	1959		1.40	2.49	3.75	5.66	7.12	9.34	9.50	7.96	4.33	2.15	0.94	39.91
Thornton 23	1960	1.67	2.18	4.19	6.08	8.84	10.60	10.55	9.08	6.76	5.14	1.92	1.30	
Mean														
Alfalfa														
Ceres 3E	1957								6.50	5.89	3.14	1.77		
Ceres 3E	1958				6.33	6.22	8.57	8.60		6.71	3.79	2.35	1.23	37.19
Ceres 3E	1959		1.55	4.35	6.85	8.51	9.61	10.00	3.05	6.05	5.73	2.52	1.82	42.22
Ceres 3E	1960	1.73	2.35	3.64	6.52	8.38	8.77	9.93	6.30	4.92	4.03	1.37	0.91	37.30
Lodi 35	1958										3.91	2.45	1.79	
Vernalis 33E	1958					7.43	7.44	9.94	2.94	6.46	4.55	2.76	1.62	37.26
Mean					6.73	7.65	8.60	9.37	6.78	6.01	4.22	2.20	1.43	
Miscellaneous														
Los Jinos Equipment Yard	1959				9.00	12.27	15.11	15.41	12.59	9.79	6.68	3.03	1.96	66.37
Los Jinos Equipment Yard	1960	1.16	2.16	4.73	7.96	11.99	16.47	16.29	14.04	9.75	6.22	1.90	0.84	68.54
Twitchell Island	1959											2.93	2.99	2.04
Twitchell Island	1960	1.59	3.03	4.24	6.19	8.36	12.38	11.57	11.13	3.17	5.70	1.96	1.23	51.64

TABLE A-2 (continued)

MONTHLY EVAPORATION FROM STANDARD
U. S. WEATHER BUREAU EVAPORATION PANS
(in inches)

Area, environment, and station name	Year of: Record	Month:											May-Sept. : total	
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.		Dec.
CENTRAL VALLEY (continued)														
TULARE LAKE BASIN VALLEY FLOOR														
Pasture	1959	1.96	2.24	4.30	5.82		9.06	9.95	8.67	5.93	4.49	2.69	1.68	
Arvin Frick	1960				8.72	9.93	9.93	9.39	8.09	6.13	4.08	1.89	1.08	42.31
Kerman 2ESE	1960				9.15	10.05	8.81	7.43	6.02		4.28	1.63	0.80	41.46
Kingsburg 5S No. 2	1958								8.56		4.25	1.88		
Kingsburg 5S No. 2	1959		2.14	4.17	5.37	8.39	9.93	9.26	7.57	5.74	4.31	2.16	1.38	40.89
Kingsburg 5S No. 2	1960	1.63	2.15	3.97	6.09	8.81	9.67	9.37	8.36	6.20	4.04	1.62	0.86	42.41
Mean		1.79	2.18	4.15	5.76	8.77	9.74	9.36	8.11	6.00	4.24	1.98	1.16	
Alfalfa	1958					6.44	8.59	9.45	9.83	4.24	5.10	2.31	1.68	38.55
Arvin Jewett No. 1	1958													
Arvin Jewett No. 2	1959	1.84	2.51	4.53	7.00	8.69			5.06	4.60	2.48	1.21	0.78	
Kingsburg 5S No. 1	1957								8.88	5.94	4.25	2.25		
Shafter 2NW	1958								7.92	4.93	3.94	1.92		
Mean														
Dryland	1960			5.73			16.15	17.83	16.60		8.41	2.90	1.35	
Panoche Junction														
LAHONTAN														
LASSEN, ALPINE MOUNTAIN VALLEYS														
Pasture	1958					5.73				5.93	4.14			
Cedarville 2E	1959					6.57		11.56	11.35	7.31	5.00	2.58		
Cedarville 2E	1960	2.16	3.17	5.46			9.01	12.01	10.33	7.76	4.82	1.60	0.36	45.68
Coleville 2W	1957						8.38	9.33	9.09	9.45	3.44			
Standish 4NW	1959					6.11	9.31	11.96	9.39	5.91				42.68
Standish 4NW	1960					6.91	8.95	10.00	8.89	7.75				42.40
Mean						6.30	8.91	10.97	9.81	6.85	4.35			
Dryland	1960					7.26	10.99	10.40	11.03	8.66				43.34
Eagle Lake Stone Ranch														

TABLE A-3

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year : : of : : record:	Months												: May- : September : total
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
<u>NORTH COASTAL</u>														
<u>KLAMATH, TRINITY MOUNTAIN VALLEYS</u>														
<u>Pasture</u>														
Montague 3NE	1959					454	575	624	531	368				2,552
Montague 3NE	1960					450	621	634	559	452				2,716
<u>Alfalfa</u>														
Calahan Towne Ranch	1955						590	582	560					
Gazelle 3NNW	1955						528	507	510					
Grenada 6E	1955					392	533	584	547					
Mean							550	558	539					
<u>Dryland</u>														
Fort Jones R. S.	1954							618	427	371				
Fort Jones R. S.	1955					320	525	566	528					
Gazalle 1NNE	1958					530	486	569	507	438				2,530
Gazalle 1NNE	1959	388				444	556	598	541	370				2,510
Gazalle 1NNE	1960					489	661	758	682	534				3,124
Hayfork R. S.	1954								466	350				
Hayfork R. S.	1955	226				462	486	493	473					
Hayfork R. S.	1956						513	630	611	416				
Hayfork R. S.	1957					432	566	582	567	466				2,613
Hayfork R. S.	1958					464	369	416	519	421				2,138
Hayfork R. S.	1959					428	537	607	513	398				2,483
Hayfork R. S.	1960						598	589	612					
Macdoel F. S.	1955						607	607	683					
Yreka 1NE	1954						398	560	491					
Yreka 1NE	1955						556	579	576	363				
Mean						446	521	584	546	413				
<u>CENTRAL VALLEY</u>														
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS</u>														
<u>Pasture</u>														
Alturas Dorris Ranch	1956					380	544	607	599	387				2,456
Alturas Dorris Ranch	1957					476	471	535	536					
Alturas Dorris Ranch	1958						547	643	501					
Alturas Dorris Ranch	1959						562	560	551	422				
Alturas Dorris Ranch	1960								501					

(in milliliters)

-91-

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year :	Months												: May -
	: of :	: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :	: September
: record:	: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :	: total	
CENTRAL VALLEY (continued)														
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)														
Dryland (continued)														
Davis Creek 4NW	1958					584	595	573	379					
Fall River Mills Intake	1956					512	575	497	512					
Fall River Mills Intake	1957				408	581								
Fall River Mills R. S.	1955					534	594	628	479	342				
Fall River Mills R. S.	1956					536	612	578	464					
Fall River Mills R. S.	1957				493	554	508	513	418					2,486
Likely 4N	1954					601	601	543	461					
Loyalton 5W	1954						616	519						
Loyalton 7N	1958				484	497	555	543						
Loyalton 7N	1959				578									
Loyalton 7N	1960					580	536							
Mt. Shasta City N.B.	1955					547	535	580	337	301				
Quincy R. S.	1954						560	507	469					
Quincy R. S.	1955						528	502	370					
West Valley Reservoir	1958							323						
West Valley Reservoir	1959					474	575	527	396					
Mean					470	536	569	540	408	310				
Miscellaneous Lands														
Adin R. S.	1955				425	554	640	589	478	300				2,686
SACRAMENTO RIVER BASIN FOOTHILLS														
Pasture														
Auburn Mt. Vernon	1958					503	623	554	463	397				
Auburn Mt. Vernon	1959				485	562	589	532	457	402				2,625
Auburn Mt. Vernon	1960				432	602	614	532	454	350				2,694
Gold Hill Doty Flat	1958					544	642	575	466	391				
Gold Hill Doty Flat	1959				471	575	625	556	441	390				2,688
Gold Hill Doty Flat	1960				450	516	628	645	515	381				2,915
Loma Rica	1960													
Penn Valley	1958					547	634	562	466	360				
Penn Valley	1959				490	610	626	552	448	387				2,745
Penn Valley	1960				391	574	567	586	484	375				2,681
Mean					292	453	494	572	466	375				

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year : : of : : record :	Months												: May - : September : total	
		: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :		
CENTRAL VALLEY (continued)															
SACRAMENTO RIVER BASIN FOOTHILLS (continued)															
Dryland															
Bella Vista 4NE	1959			404	437	494	674	493	393	343				2,491	
Bella Vista 4NE	1960	272	330	436	436	535			353	350				2,769	
Newville	1959	383	437	499	595	632		573	470	409				3,176	
Newville	1960	314	410	501	681	667		713	614	451					
Mean		323	395	468	576	658		593	458	388					
SACRAMENTO RIVER BASIN VALLEY FLOOR															
Pasture															
Anderson 4E	1958						602	563	483	385					
Anderson 4E	1959	377	433	466	548	592	540	515	421	356				2,558	
Anderson 4E	1960	284	357	442	572	598	633	562	462	308				2,548	
Corning 3NE	1960	326	417	476	568	608	653	597	514	398				2,701	
Davis Campbell #1	1960			532	608	653	597	550	391	358				2,904	
Elk Grove 4NW	1960	331	448	530	594	587	550	591	493	425				2,652	
Lincoln Vineyard	1958				599	662	579	546	459	383				2,683	
Lincoln Vineyard	1959	283	407	454	554	555	512	440	349					2,515	
Lincoln Vineyard	1960	310	426	499	594	635	602	474	378					2,804	
Palermo 3SW	1960	369	460	481	641	680	544	444	376					2,790	
Red Bluff Cone Ranch	1959	301	393	487	600	606	499	412	323					2,604	
Red Bluff Cone Ranch	1960	339	429	519	601	591	530	427	337					2,668	
Yuba City 9W	1960	324	424	491	588	614	549	443	366						
Mean															
Alfalfa															
Anderson 3E	1955			584	513	623		572	504	352				2,796	
Anderson 2E	1958		406	552	542	602	602	563	483	385				2,742	
Arbuckle 1S	1958		489	561	552	601	557	483	452					2,754	
Arbuckle 1S	1959	404	450	497	589	609	508	416	357					2,619	
Arbuckle 1S	1960	330	392	504	555	559	516	430	334					2,564	
Corning Jobe	1958		430	561	572	644	611	481	454					2,869	
Corning Jobe	1959		463	524	604	660	573	456	381					2,817	
Hamilton City	1955		609	609	649	680	618	531	423					3,087	
Red Bluff 3E	1958		445	532	567	578	526	521	342					2,724	
Rocklin Igarashi	1958				558	612	552	487	417						

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS

(in milliliters)

Area, environment, and station name	: Year : : of : : record:	: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :	: May - : September : total
CENTRAL VALLEY (continued)														
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)														
Alfalfa (continued)														
Rocklin Igarashi	1959				472	531	563	628	565	442	369			2,729
Rocklin Igarashi	1960	327			436	504	606	584	529	448	346			2,671
Vina Beck	1958				449	546	615	644	581	445	419			2,831
Vina Beck	1959	440			446	507	579	612	552	457	379			2,707
Vina Beck	1960				448	530	615	592	498					
Yuba City	1958				416	535	559	648	576	521	426			2,839
Yuba City	1959	417			488	545	619	634	551	451	390			2,800
Mean		384			445	539	580	618	556	472	389			
Dryland														
Davis Campbell #2	1960								537	435	351			
Mills Orchard	1954									459	373			
Mills Orchard	1955				327	555	547	601	570	469	362			2,740
Oroville Agri. Comm.	1959	386			471	516	607	685	647	485	425			2,808
Redding GSE	1955									492	395			3,001
Redding GSE	1956					452	559	611	516	412				2,550
Redding GSE	1957					461	625	595	485	379	252			
Redding GSE	1958					500	506	590	550					
Redding Stayer	1958									500	397			2,921
Redding Stayer	1959	389			449	491	633	739	602	456	396			2,809
Redding Stayer	1960	281			373	470	632	677	567	463	316			
Sacramento Refuge	1955								641	529	421			
Sacramento Refuge	1956				407	503	613	690	609	481	336			2,896
Sacramento Refuge	1957					533	638	681	618	486	330			2,956
Sacramento Refuge	1958				458	538	589	659	573	457	357			2,816
Sacramento Refuge	1959	419			489	539	637	662	559	481	405			2,878
Sacramento Refuge	1960	353			434	518	623	623	570	464	371			2,798
Mean		366			426	511	588	655	573	465	366			
Miscellaneous Lands														
Corning 3NW	1954								546	525	414			
Live Oak 3SE	1954							540	478	421	338			
Pennington 3NW	1960								526	435	325		162	
Redding A. P.	1957					427	474		554	324	275			

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS

(in milliliters)

Area, environment, and station name	: Year :	Months												: May- September total
		: of :	: Jan. :	: Feb. :	: Mar. :	: Apr. :	: May :	: June :	: July :	: Aug. :	: Sept. :	: Oct. :	: Nov. :	: Dec. :

CENTRAL VALLEY (continued)

SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)

Miscellaneous Lands (continued)														
Richvale 1E	1957									668	428	314		
Richvale 1E	1958									579	441	349		2,827
Richvale 1E	1959	355	446	549	603	655	703	613	573	573	451	390		2,873
Richvale 1E	1960	309	425	516	639	636	612	474	612	567	442	370	179	2,877
Mean			403	511	581	628						351		

SAN JOAQUIN RIVER BASIN VALLEY FLOOR

Pasture														
Berenda 2N	1959									571	471	413		2,788
Berenda 2N	1960	353	441	528	598	620	511	495	515	436	347			2,538
El Solyo Ranch	1959	427	476	531	590	610	515	452	447	452	366			2,665
El Solyo Ranch	1960	362	438	528	583	591	547	452	515	448	350			2,701
Lodi 3SW	1959	402	454	479	486	535	515	427	388	359	341			2,463
Merced 5SE	1959	415	475	515	588	576	536	427	388	442	359			2,642
Merced 5SE	1960	371	457	526	578	541	442	321	366	426	321			2,654
Newman 1SE	1960				543	542	533	444	378	444	378			
Stockton 9S	1959		481	484	523	587	535	484	354	484	354			2,573
Stockton 9S	1960	310	442	612	588	612	618	495	364	495	364			2,914
Thorncton 2S	1960	356	480	546	625	631	543							2,861
Mean		374	460	529	569	580								

Alfalfa														
Atwater 1N	1958									566	475	359		2,831
Atwater 1N	1959	372	471	584	598	608	606	557	435	452	395			2,747
Atwater 1N	1960	345	412	541	553	479	519	503	414	435	354			2,527
Ceres 3E	1958									563	453			2,710
Ceres 3E	1959	400	529	559	542	592	513	379	335	379	335			2,534
Ceres 3E	1960	373	445	569	600	577	554	501	402	501	388			2,801
Lodi 3S	1958									573	459			
Lodi 3S	1959	417	472	503	478	572	522	467	419	467	419			2,542
Los Banos 3S	1958									552	449			
Los Banos 8SE	1958									578	482			
Stockton 8S	1958									614	356			

TABLE A-3 (continued)

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

Area, environment, and station name	: Year : : of : : record	Months												: May - : September : total
		: Jan.	: Feb.	: Mar.	: Apr.	: May	: June	: July	: Aug.	: Sept.	: Oct.	: Nov.	: Dec.	
CENTRAL VALLEY (continued)														
SAN JOAQUIN RIVER BASIN VALLEY FLOOR (continued)														
Alfalfa (continued)														
Stockton 8S	1959	400		435	514	577	606	524	435	362				2,656
Vernalis 3SE	1958				581	567	576	532	476	359				2,732
Mean		284		470	548	571	582	548	454	379				
Miscellaneous Lands														
Los Banos Equip. Yard	1959			455	468	533	561	421	394	283				2,377
Los Banos Equip. Yard	1960	289		388	496	460	447	476	432	356				2,311
TULARE LAKE BASIN VALLEY FLOOR														
Pasture														
Arvin Frick	1959					571	582	548	473	413		293		
Arvin Frick	1960			438	570	670	639	582	480	372		223		2,941
Kerman 2ESE	1960				490	536	540	516	415	343		176		2,497
Kingsburg 5S #2	1958					599	611	638	469	407				
Kingsburg 5S #2	1959	421		455	517	544	604	529	431	371				2,625
Kingsburg 5S #2	1960			427	502	511	507	494	395	330				2,409
Mean				440	520	572	580	551	444	313		231		
Alfalfa														
Arvin Jewett #1	1958				555	571	610	551	460	378				2,747
Arvin Jewett #2	1959	390		473	498	586	664	540	400	408				2,778
Fresno Kearney Park	1958				588	605	600	551	421	365				2,671
Fresno Kearney Park	1959			432	494	605	600	551	421	365				
Fresno Kearney Park	1960	406		424										
Mendota Murietta Ranch	1958			516	534	587	643	541	434	511				2,739
Mendota Murietta Ranch	1959			473	561	595	590	561	456	420				2,763
Mendota Murietta Ranch	1960	410		452				593	502	371				
Shafter 2NW	1958						596	605	456	407				
Mean		402		462	538	589	617	563	447	409				

Dryland

MONTHLY EVAPORATION DIFFERENCES BETWEEN
LIVINGSTON SPHERICAL BLACK AND WHITE ATMOMETERS
(in milliliters)

-97-

TABLE A-4

LOCATION OF EVAPOTRANSPIRATION
MEASURING STATIONS

Area and station name	Crop	MD&M	County	Location	Description
KLAMATH-TRINITY MOUNTAIN VALLEYS					
Gazelle Dougherty #1	Alfalfa	T43N R6W 22W1	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
Gazelle Dougherty #2	Alfalfa	T43N R6W 22W2	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
Gazelle Dougherty #3	Alfalfa	T43N R6W 21W1	Siskiyou	C. C. Dougherty Ranch, 3-1/2 mi. NW of Gazelle	
NORTH COASTAL					
CENTRAL VALLEY					
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS					
Alturas Dorris Ranch	Pasture	T42N R13E 19W1	Modoc	Dorris Ranch, 2 mi. SE of Alturas	
Bieber 3E	Alfalfa	T38N R8E 18W1	Lassen	Earl Leonard Ranch, 3 mi. E of Bieber	
Bieber Leonard	Alfalfa	T38N R8E 17W1	Lassen	Francis Leonard, 4 mi. E of Bieber	
Canby Bushey	Alfalfa	T42N R9E 8W1	Modoc	R. Bushey Ranch, 5 mi. SW of Canby	
Hat Creek Kern	Alfalfa	T34N R4E 11W1	Shasta	B. S. Kern Ranch, 4 mi. N of Hat Creek	
Hat Creek Opdyke	Alfalfa	T34N R4E 15E1	Shasta	P. Opdyke Ranch, 2 mi. NW of Hat Creek	
McArthur Albaugh #1	Alfalfa	T37N R5E 11W1	Shasta	C. A. Albaugh Ranch, 1 mi. W of Pittville	
McArthur Albaugh #2	Alfalfa	T37N R5E 11W2	Shasta	C. A. Albaugh Ranch, 1 mi. W of Pittville	
McArthur 1 NE	Alfalfa	T37N R5E 9W1	Shasta	J. McArthur Ranch, 1/2 mi. NE of McArthur	
Pittville 1S	Alfalfa	T37N R5E 13W1	Shasta	L. Owens Ranch, 1 mi. S of Pittville	
Pittville (AA)	Alfalfa	T37N R5E 13W2	Shasta	L. Owens Ranch, 1 mi. S of Pittville	
McArthur (AB)	Alfalfa	T37N R5E 16W1	Shasta	J. McArthur Ranch, 1 mi. SE of McArthur	
SACRAMENTO RIVER BASIN VALLEY FLOOR					
Davis Campbell	Regrass	T8N R2E 17W1	Yolo	Campbell Tract, Univ. of Calif. at Davis	
Anderson 2N	Alfalfa	T30N R4W 10W1	Shasta	Floyd Leonard Ranch, 2 mi. N of Anderson	
Anderson 3E	Alfalfa	T30N R3W 8W1	Shasta	R. Haller Ranch, 3 mi. E of Anderson	
Anderson Trisdale	Alfalfa	T30N R3W 8W1	Shasta	J. H. Trisdale Ranch, 4 mi. E of Anderson	
Mills Orchard	Alfalfa	T22N R2W 30W1	Glenn	Mills Orchard Co., 2 mi. W of Hamilton C.	
Redding 6SE	Alfalfa	T31N R4W 15W1	Shasta	L. A. Stayer Ranch, 6 mi. SE of Redding	

TABLE A-4 (Continuing)
LOCATION OF EVAPOTRANSPIRATION
MEASURING STATIONS

Area and station name	Crop	MD&M	County	Location	Description	
<u>CENTRAL VALLEY (continued)</u>						
<u>TULARE LAKE BASIN VALLEY FLOOR</u>						
Arvin (CE)	Grass	T31S	R29E	16F1	Kern	Howard Frick Ranch, 2-1/2 mi. NW of Arvin
Arvin Jewett	Alfalfa	T31S	R29E	16H1	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin
Arvin Jewett #2	Alfalfa	T31S	R29E	16H2	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin
Arvin Jewett #3	Alfalfa	T31S	R29E	16H3	Kern	H. S. Jewett Ranch, 4 mi. NW of Arvin
Arvin (CC)	Alfalfa	T31S	R29E	16F2	Kern	Howard Frick Ranch, 2-3/4 mi. NW of Arvin
Arvin (CB)	Plums	T31S	R29E	10N1	Kern	DiGiorgio Farms, 4 mi. NW of Arvin
Arvin (CD)	Cotton	T31S	R29E	9N1	Kern	Howard Frick Ranch, 3 mi. NW of Arvin
Arvin (CF)	Cotton	T31S	R29E	16D1	Kern	Howard Frick Ranch, 3 mi. NW of Arvin
<u>LASSEN-ALPINE MOUNTAIN VALLEYS</u>						
Coleville 2W	Pasture	T8N	R22E	3K1	Mono	P. Spring Ranch, 2 mi. W of Coleville
Leavitt Lake	Alfalfa	T29N	R13E	16N1	Lassen	P. Milton Ranch, 10 mi. SE of Susanville

TABLE A-5

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of irrigation	Dates of cutting or harvesting	Approximate: growing season	Correlative: Eleva-tographic station
<u>NORTH COASTAL</u>								
<u>KIAMATH-TRINITY MOUNTAIN VALLEYS</u>								
<u>ALFALFA</u>								
Gaselle Dougherty #1	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 19 June 28 July 5 Aug. 16, 29	June 12 July 31 Sept. 26	May 1 - Sept. 20	Gaselle 30NW
Gaselle Dougherty #2	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 17 June 27 July 4 Aug. 14, 28	June 12 July 30 Sept. 26	May 1 - Sept. 20	Gaselle 30NW
Gaselle Dougherty #3	1955	Sandy loam 0-7 feet.	Three gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	Apr. 6 May 18 June 27 July 4 Aug. 14, 28	June 12 July 31 Sept. 26	May 1 - Sept. 20	Gaselle 30NW
<u>SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS</u>								
<u>PASTURE</u>								
Alturas Dorris Ranch	1959 1960	Undisturbed clay loam throughout.	Inflow-outflow evapotranspirometer.	Continuous surface application high water table level maintained.	Continuous		May 15 - Sept. 15	Alturas Dorris Ranch
<u>ALFALFA</u>								
Bieber 3E	1955	Fine sandy loam overlying relatively impervious consolidated material at $\frac{3}{4}$ feet.	Four gravimetric sampling stations. Total sampling depth, 3 $\frac{1}{2}$ feet.	Sprinkler	July 1 Aug. 29	July 8 Aug. 17	May 15 - Sept. 15	Bieber S.C.S.

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Date of irrigation	Dates of cutting or harvesting	Approximate growing season	Relative Evapotranspiration station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)								
ALPALZA (continued)								
Bieber Leonard	1956	Sandy loam 0-18". Partially cemented sandy loam 18-36". Loamy sand 36-68". Distinctive earth below 68".	Sixteen gravimetric sampling stations. Total sampling depth, 7 feet.	Sprinkler	July 3, 19 Aug. 27	July 1 Aug. 18	May 15 - Sept. 15	Bieber LE 4,200
Canby Bunhey	1955	Clay loam 0-8 feet.	Three gravimetric sampling stations. Total sampling depth, 8 feet.	Wild flooding	July 15 Aug. 21 Sept. 26	July 8 Sept. 2	May 15 - Sept. 15	Canby R.S. 4,300 (est.)
Hat Creek Kern	1955	Sandy loam underlain by coarse sand at four feet. Water table at 6 feet.	One gravimetric sampling station. Total sampling depth, 6 feet.	Border irrigation. Length of run, 1,000 feet.	May 18 June 9, 28 July 18 Aug. 8, 21 Aug. 29 Sept. 18	July 5 Sept. 1	May 1 - Sept. 30	Hat Creek JM 3,350 (est.)
Hat Creek Opdyke	1955	Fine sandy loam underlain by sand and gravel at 4 feet. Water table at 6 feet.	One gravimetric sampling station. Total sampling depth, 4 feet.	Border irrigation. Length of run, 500 feet.	May 24 June 8 July 5, 24 Aug. 14 Sept. 6	July 6 Aug. 29	May 1 - Sept. 30	Hat Creek JM 3,350 (est.)
McArthur Albaugh #1	1955	Sandy loam 0-13' underlain by coarse sand.	Two gravimetric sampling stations. Total sampling depth, 7 feet.	Wild flooding.	May 11 June 2, 28 July 17 Aug. 19 Oct. 2	June 16 Aug. 6 Sept. 13	April 15 - Oct. 15	McArthur 2E 3,325
McArthur Albaugh #1	1956	Sandy loam 0-13 feet underlain by coarse sand.	Sixteen gravimetric sampling stations. Total sampling depth, 9 feet.	Wild flooding.	April 27 June 21 July 17 Aug. 13 Sept. 13	June 7 July 23 Sept. 4	April 1 - Sept. 30	McArthur 2E 3,325
McArthur Albaugh #2	1956	Sandy loam 0-9' underlain by clay.	Twelve gravimetric sampling stations. Total sampling depth, 9 feet.	Wild flooding.	April 27 June 21 July 17 Aug. 13 Sept. 13	Oct. 3	April 1 - Sept. 30	McArthur 2E 3,325

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Date of irrigation	Date of cutting or harvesting	Approximate season	Correlative Evapotranspiration station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)								
ALFAFA (continued)								
McArthur 1M	1955	Sandy loam 0-3' underlain by sand. 18". Water table at 19'.	One gravimetric sampling station. Total sampling depth, 4 feet.	Border irrigation. Length of run, 1,200 feet.	May 21 June 15 July 19 Aug. 2, 11, 24	June 7 July 25 Sept. 5	April 1 - Sept. 30	3,350 McArthur 2E
Pittville 1S	1956	Sandy loam underlain by coarse sand at 18". Water table at 19'.	Eight gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 16 June 29 July 20 Aug. 14 Sept. 5	June 16 July 27 Sept. 12	April 1 - Sept. 30	3,300 McArthur 2E
Pittville 1S	1957	Sandy loam underlain by coarse sand at 18". Water table at 19'.	Eight gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 14 June 25 Aug. 16, 27 Sept. 5	June 7 Aug. 5 Sept. 17	April 15 - Oct. 15	3,300 Pittville 1S
Pittville 1S	1958	Sandy loam underlain by coarse sand at 18". Water table at 19'.	Five gravimetric sampling stations. Total sampling depth, 9 feet.	Sprinkler	May 23 July 19 Aug. 29	June 19 Aug. 4 Sept. 25	April 15 - Oct. 15	3,300 Pittville 1S
Pittville (AA)	1959	Sandy loam underlain by coarse sand at 18". Dense clay at 20'.	Neutron scattering.	Sprinkler	Shown in Table 8	June 15 Aug. 1 Sept. 23	April 15 - Oct. 15	3,300 Pittville 1S
Pittville (AA)	1960	Sandy loam underlain by coarse sand at 18". Dense clay at 20'.	Neutron scattering.	Sprinkler	Shown in Table 8	June 10 July 18 Sept. 15	April 15 - Oct. 15	3,300 Olenburn DWR
McArthur (AB)	1959	Stratified loam and clay loam 0-20 feet.	Neutron scattering.	Sprinkler	Shown in Table 8	May 25 July 10 Aug. 13 Sept. 25	April 15 - Oct. 15	3,350 Pittville 1S
McArthur (AB)	1960	Stratified loam and clay loam 0-20 feet.	Neutron scattering.	Sprinkler	Shown in Table 8	June 1 July 5 Aug. 17 Sept. 30	April 15 - Oct. 15	3,350 Olenburn DWR

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPORIMETER MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of cutting or irrigation	Dates of harvesting	Approximate growing season	Correlative Elevations station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN VALLEY FLOOR								
<u>RYEGRASS</u>								
Davis Campbell	1958	Disturbed Yolo loam. Uniform throughout.	Weighting type evapo-transpirometers.	Sprinkler	Sept. 12, 27 Oct. 30	Sept. 16 Oct. 29 Dec. 2	Mar. 1 - Oct. 31	50 Davis-Campbell, #1
Davis Campbell	1959	Disturbed Yolo loam. Uniform throughout.	Weighting type evapo-transpirometers.	Sprinkler	Apr. 27-29 May 19-22 June 5-7 June 19-20, 28-29 July 11-13 July 21-23 July 31-Aug. 1 Aug. 11-12, 26, 31 Aug. 21-22 Sept. 1-2 Sept. 13-14 Oct. 4-5 31-Nov. 1 Nov. 6-7	Mar. 17 Apr. 20 May 6, 15 June 5, 16, 24 July 6, 16, 27 Aug. 10, 17 Sept. 11, 23 Oct. 14 Nov. 6 Dec. 1	Mar. 1 - Oct. 31	50 Davis-Campbell, #1
Davis Campbell	1960	Disturbed Yolo loam. Uniform throughout.	Weighting type evapo-transpirometers.	Sprinkler	April 12, 16, 29 May 9 June 3, 12, 19, 20, 28, 29, 30 July 11, 17	Mar. 31 Apr. 8, 15 May 4, 16, 31 June 10, 17, 27 July 6, 13	Mar. 1 - Oct. 31	50 Davis-Campbell, #1
<u>ALFALFA</u>								
Anderson 2B	1955	Sandy loam underlain by loamy sand at 51. Sand and cobble at 8-10 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Sprinkler	May 25 June 4, 14 July 12 Aug. 9, 20 Aug. 28	May 19 June 31 Sept. 8 Oct. 21	April 1 - Nov. 1	390 Anderson 3E (est.)
Anderson 3B	1955	Sandy loam 0-5 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation. Length of run, 400 feet.	May 27 July 5 Sept. 22	May 17 June 20 Aug. 3 Sept. 6	March 15 - Nov. 1	390 Anderson 3F (est.)

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of irrigation	Dates of cutting or harvesting	Approximate date of growing season	Correlative elevation-station
CENTRAL VALLEY (continued)								
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)								
ALPALPA (continued)								
Anderson Triadale	1955	Sandy clay loam 0-10 feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation. Length of run, 600 feet.	May 31 July 10 Aug. 4 Oct. 9	May 16 June 20 July 28 Sept. 25	April 1 - Nov. 1 1950 (est.)	Anderson 3E
Mills Orchard	1955	Silty clay loam underlain by fine sandy loam at 5½ feet.	One gravimetric sampling station. Total sampling depth, 7 feet.	Border irrigation. Length of run, 1,200 feet.	Apr. 9 May 15 June 11, 19 July 10, 21 Aug. 16 Sept. 20	Apr. 15 June 4 Aug. 3 Sept. 9 Oct. 12	March 15 - Nov. 1 1951	Wills Orchard
Redding GSE	1955	Reddish clay loam interreplaced with cobble.	One gravimetric sampling station. Total sampling depth, 4 feet.	Sprinkler	Apr. 5 May 17, 30 June 18 Aug. 5 July 2, 11, 28 Aug. 13, 23 Sept. 3, 27	May 18 June 26 Aug. 5 Sept. 19	April 1 - Nov. 1 1951	Peddine GSE
TULARE LAKE BASIN VALLEY FLOOR								
GNSS								
Arvin (CE)	1959	Hesperia fine sandy loam, fairly uniform. 0-12 feet overlying stratified layers varying in texture from sand to clay loam.	Neutron scattering	Border irrigation. Length of run, 440 feet.	Shown in Table 8	Moved every two weeks.	Jan. 1 - Dec. 31	Arvin-Frick
Arvin Jewett	1957-58	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation. Length of run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 29 May 25	Feb. 1 - Nov. 30 1958	Arvin Jewett #1
Arvin Jewett #2	1957-58	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation. Length of run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 28 May 25	Feb. 1 - Nov. 30 1958	Arvin Jewett #1
Arvin Jewett #3	1958	Hesperia fine sandy loam, fairly uniform throughout 0-9 feet.	Ten gravimetric sampling stations. Total sampling depth, 9 feet.	Border irrigation. Length of run, 1,300 feet.	Feb. 7 May 20, 30	Mar. 28 May 25	Feb. 1 - Nov. 30 1958	Arvin Jewett #3

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of : measure- : ment	Soil profile characteristics	Moisture measurement : techniques	Method of : irrigation	Dates of : cutting or : harvesting	Approximate : growing : season	Elevation : station	Correlative : station
CENTRAL VALLEY (continued)								
TULARE LAKE BASIN VALLEY FLOOR (continued)								
ALFALFA (continued)								
Arvin (Cc)	1959	Hesperia fine sandy loam 0-12 feet overlying stratified layers varying in texture from sand to clay loam.	Neutron scattering.	Border irrigation. Length of run, 440 feet.	Shown in Table 8 Mar. 12 Apr. 10 May 16 June 15 July 11 Aug. 8 Sept. 5 Oct. 17	Feb. 15 - Dec. 15	437	Arvin Jewett #2 and Arvin Frick
Arvin (Cc)	1960	Hesperia fine sandy loam 0-12 feet overlying stratified layers varying in texture from sand to clay loam.	Neutron scattering.	Border irrigation. Length of run, 440 feet.	Shown in Table 8 Mar. 21 Apr. 20 May 23 July 24 Aug. 25 Sept. 26	Feb. 15 - Dec. 15	437	Arvin Frick
PEACHES								
Arvin (Cb)	1959	Hesperia fine sandy loam 0-18 feet overlying sand.	Neutron scattering.	Burrow irrigation. Length of run, 325 feet.	Shown in Table 8 June 8	Mar. 1 - Nov. 30	470	Arvin Jewett #2 and Arvin Frick
Arvin (Cb)	1960	Hesperia fine sandy loam 0-18 feet overlying sand.	Neutron scattering.	Burrow irrigation. Length of run, 325 feet.	Shown in Table 8 June 14	Mar. 1 - Nov. 30	470	Arvin Frick
COTTON								
Arvin (Cb)	1959	Hesperia fine sandy loam, fairly uniform 0-10 feet overlying sandy loam stratified with sand and clay layers.	Neutron scattering.	Burrow irrigation. Length of run, 440 feet.	Shown in Table 8 Nov. 5 Dec. 12	Apr. 1 - Oct. 31	440	Arvin Jewett #2 and Arvin Frick
Arvin (Cb)	1960	Hesperia fine sandy loam, fairly uniform 0-10 feet overlying sandy loam stratified with sand and clay layers.	Neutron scattering.	Burrow irrigation. Length of run, 440 feet.	Shown in Table 8 Nov. 30, 1960 Jan. 12, 1961	Apr. 1 - Oct. 31	435	Arvin Frick

TABLE A-5 (continued)

GENERAL INFORMATION RELATIVE TO EVAPOTRANSPIRATION MEASURING STATIONS

Area, crop, and station name	Year of measurement	Soil profile characteristics	Moisture measurement techniques	Method of irrigation	Dates of irrigation	Dates of cutting or harvesting	Approximate season	Correlative Elev.-macroclimatic station
<u>LARAMIE MOUNTAIN VALLEYS</u>								
<u>PASTURE</u>								
Coleville 24	1957	Peat 0-1½ feet, underlain by sandy loam.	Evapotranspirometer	Continuous sub- irrigation with variable high water table levels.	Continuous		April 15 - Sept. 15	Coleville 24
<u>ALFALFA</u>								
Leavitt Lake	1955	Loam 0-9', silty clay loam 9-13', Compact silt 13-16', Sand 16-18'. Water table 11-16'.	Four gravimetric sampling stations. Total sampling depth, 6-8 feet.	Border irriga- tion. Length of run, 1,200 feet.	May 1 July 26 Aug. 15, 27	Aug. 1 Sept. 27	May 15 - Sept. 15	Leavitt Lake

NEUTRON PROBE MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA FOR SEVERAL IRRIGATED CROPS.[illegible]

TABLE A-6 (continued)
NEUTRON PROBE MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA FOR SEVERAL IRRIGATED CROPS,
1959 and 1960

Area, crop, station, name, number, date, period of study, days	Depth of applied water	Soil moisture determination				Evapotranspiration (E _p), in inches				Black minus white, anemometer evaporation, in millimeters				Crop development			
		Moisture depth, inches	change, inches	depth, inches	depth, inches	Mean, inches	Mean, inches	Mean, inches	Mean, inches	Mean, inches	Mean, inches	Mean, inches	Plant height, inches	Plant stage, inches	Plant stage, inches	Plant stage, inches	
TULARE LAKE BASIN (continued)																	
Grass Arvin (CE), 1959																	
7/24																	
7/31	7	3	2.19	0.24	0.00	2.19	0.31	2.44	44.46	0.90	136	2.588	0.0161	90	9	0-3	4.89
8/7	8	5	2.19	0.84	0.00	0.78	2.97	40.86	46.92	2.46	40	2.568	---	90	11	0-3	2.70
8/11	8	8	8/11	NR	0.00	2.10	5.07	2.46	46.92	154	2.722	---	---	NR	NR	NR	NR
8/28	2	3	1.45	0.22	0.00	1.90	6.97	8.22	49.14	0.82	145	2.867	---	85	9	0-3	4.21
8/28	2	5	3	1.45	0.22	0.00	8.42	0.21	50.90	0.31	177	2.978	0.0131	85	12	0-3	2.76
8/31	3	3	1.95	0.22	0.00	0.51	8.93	0.52	51.32	37	3.015	---	---	NR	NR	---	---
9/6	15	3	1.95	0.22	0.00	1.12	13.02	0.14	57.69	0.71	255	3.322	0.0090	95	15	0-3	6.47
9/16	12	3	1.68	0.34	0.00	13.50	0.14	2.40	57.69	0.70	191	3.513	0.0088	70	4	0-3	2.69
TOTALS	66		7.27	0.34	7.61	5.89	13.50	16.74	1.121								
Alfalfa Arvin (CE), 1960																	
1/4																	
2/24	49	2/24	4.58	3.86	2.62	2.62	3.86	2.62	3.86	2.62	---	---	---	---	---	---	---
3/9	13	4	1.02	0.40	1.16	2.18	0.11	2.06	7.88	0.76	---	---	---	70	7	---	---
3/28	13	4	1.02	0.40	1.16	2.18	0.11	2.06	7.88	0.76	---	---	---	---	---	---	---
4/8	11	4/8	3.00	0.55	---	---	---	---	9.95	---	---	---	---	---	---	---	---
5/17	38	5/17	4.72	---	---	---	---	---	13.64	---	---	---	---	---	---	---	---
6/2	8	6/2	2.07	0.22	---	---	---	---	23.40	0.88	---	---	---	85	7	---	---
6/3	1	6/3	3.80	---	---	---	---	---	23.77	---	---	---	---	---	---	---	---
6/7	4	6/7	---	---	---	---	---	---	25.37	---	---	---	---	---	---	---	---
6/21	14	6/21	4.03	0.85	---	---	---	---	29.93	0.70	---	---	---	90	8	---	---
6/30	9	6/30	3.22	---	---	---	---	---	32.87	---	---	---	---	90	10	---	---
7/12	12	7/12	4.37	---	---	---	---	---	36.65	---	---	---	---	90	10	---	---
7/22	10	7/22	3.43	---	---	---	---	---	36.65	---	---	---	---	---	---	---	---
8/8	6	8/8	3.64	---	---	---	---	---	40.89	---	---	---	---	90	12	---	---
8/18	7	8/18	8.35	---	---	---	---	---	44.36	---	---	---	---	---	---	---	---
8/29	11	8/29	8.35	---	---	---	---	---	47.03	0.97	---	---	---	90	10	---	---
9/1	3	9/1	---	---	---	---	---	---	49.84	0.67	---	---	---	95	10	---	---
9/7	3	9/7	---	---	---	---	---	---	50.52	---	---	---	---	95	7	---	---
9/8	1	9/8	4.23	---	---	---	---	---	50.85	0.88	---	---	---	95	16	---	---
9/12	4	9/12	---	---	---	---	---	---	52.08	---	---	---	---	---	---	---	---
9/28	16	9/28	3.82	---	---	---	---	---	52.87	---	---	---	---	95	20	---	---
9/29	1	9/29	---	---	---	---	---	---	56.12	0.65	---	---	---	100	23	---	---
10/11	12	10/11	4.01	---	---	---	---	---	56.34	---	---	---	---	---	---	---	---
10/25	10	10/25	---	---	---	---	---	---	56.21	---	---	---	---	100	12	---	---
11/29	28	11/29	---	---	---	---	---	---	56.00	1.28	---	---	---	100	12	---	---
12/8	10	12/8	---	---	---	---	---	---	58.56	0.61	---	---	---	100	14	---	---
12/18	33	12/18	---	---	---	---	---	---	62.72	0.55	---	---	---	100	14	---	---
12/20	33	12/20	---	---	---	---	---	---	62.72	0.55	---	---	---	100	14	---	---
TOTALS	196		8.99	2.81	11.80	5.34	19.48	1.906									
(8/8/60 1/10/61)	24.10																
Alfalfa Arvin (CE), 1959																	
2/21	7	2/21	---	---	---	---	---	---	5.86	---	---	---	---	---	---	---	---
3/13	34	3/13	---	---	---	---	---	---	5.86	---	---	---	---	---	---	---	---
3/27	34	3/27	---	---	---	---	---	---	5.86	---	---	---	---	---	---	---	---
TOTALS	75		---	---	---	---	---	---	11.72	---	---	---	---	---	---	---	---
(8/8/59 1/10/60)	24.10																

NEUTRON PROBE MEASUREMENTS OF EVAPOTRANSPIRATION
AND RELATED DATA FOR SEVERAL IRRIGATED CROPS,
1959 AND 1960[illegible]

FOR SEVERAL IN
959 AND 1960

TULARE LAKE BASIN (continued)

TULARE LAKE BASIN (continued)

[illegible]

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches					Atmosphere evaporation, in milliliters	ET / Eb-v	Pan evaporation, in inches	
			Tank 1	Tank 2	Tank 3	Mean	daily				Black
CENTRAL VALLEY											
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS											
Pasture Alturas-Dorris Ranch 2/5/	1929										
	Apr. 7	-	----	----	----	----	----	----	----	----	----
	Apr. 14	7	1.21	1.27	----	1.24	0.18	----	----	----	1.34
	Apr. 21	7	1.49	1.28	----	1.39	0.20	----	----	----	1.34
	Apr. 30	9	1.32	1.49	----	1.40	0.16	----	----	----	1.67
	May 5	5	0.66	0.89	----	0.77	0.15	----	----	----	1.29
	May 12	7	1.49	1.30	----	1.39	0.20	----	----	----	1.34
	May 19	7	1.37	1.46	----	1.42	0.20	----	----	----	1.27
	May 26	7	1.81	1.49	----	1.65	0.24	----	----	----	1.36
	May 31	5	0.68	0.83	----	0.76	0.15	----	----	----	0.83
	June 2	2	0.58	0.67	----	0.62	0.31	----	----	----	0.48
	June 9	7	2.18	2.20	----	2.19	0.31	425	114	0.0192	1.74
	June 16	7	2.23	2.04	----	2.14	0.31	524	383	0.0151	2.01
	June 23	7	2.51	2.26	----	2.38	0.34	516	363	0.0156	2.12
	June 30	7	1.54	1.70	----	1.62	0.23	350	248	0.0160	1.59
July 7	7	2.48	2.39	----	2.44	0.35	552	401	0.0161	2.57	
July 14	7	2.41	2.40	----	2.41	0.34	556	383	0.0157	2.00	
July 21	7	2.64	2.80	----	2.72	0.39	536	394	0.0191	1.98	
July 28	7	2.05	2.06	----	2.06	0.29	517	394	0.0151	1.87	
July 31	3	0.79	0.85	----	0.82	0.27	876	677	0.0145	0.89	
Aug. 4	4	1.30	1.39	----	1.34	0.34	460	346	0.0118	1.46	
Aug. 11	7	2.21	1.98	----	2.10	0.30	428	336	0.0255	1.97	
Aug. 18	7	1.99	2.48	----	2.24	0.32	548	413	0.0166	1.99	
Aug. 25	7	1.49	1.58	----	1.54	0.22	372	265	0.0144	1.47	
Aug. 31	6	1.84	1.31	----	1.57	0.26	423	324	0.0159	1.76	

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period			Anemometer		ET/ Evapora- tion Ep, in inches	Pan : evapora- tion Ep, in inches
			of measurement, in inches	Mean : daily	Mean : daily	evaporation, in milliliters	ET/ Evapora- tion Ep, in inches		
			Tank 1 : Tank 2 : Tank 3	Mean	Mean	Black	White	ET	Pan
CENTRAL VALLEY (continued)									
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)									
<u>Pasture (continued)</u> <u>1959</u>									
Alturas Ranch 57/ (continued)	Sept. 1	1	0.23	0.24	0.23	0.23	0.23	0.0130	0.07
	Sept. 8	7	1.43	1.37	1.40	0.20	0.20	0.0110	1.70
	Sept. 15	7	1.42	1.34	1.38	0.20	0.20	0.0144	1.74
	Sept. 22	7	0.85	0.68	0.77	0.11	0.11	0.0104	0.84
	Sept. 30	8	1.33	0.91	1.12	0.14	0.14	---	1.06
	Oct. 6	6	0.85	0.77	0.81	0.14	0.14	---	0.95
	Oct. 13	7	0.25	0.29	0.27	0.04	0.04	---	0.68
	Oct. 20	7	0.66	0.50	0.58	0.08	0.08	---	0.94
	Oct. 27	7	0.41	0.59	0.50	0.07	0.07	---	0.61
	Oct. 31	4	0.94	0.04	0.49	0.12	0.12	---	0.82
	Nov. 2	2	0.70	0.04	0.37	0.18	0.18	---	0.62
<u>1960</u>									
	Apr. 8	8	---	---	---	---	---	---	---
	Apr. 11	3	0.46	---	---	0.15	0.15	---	0.59
	Apr. 18	7	0.61	0.79	0.70	0.10	0.10	---	0.95
	Apr. 25	7	0.47	0.60	0.54	0.08	0.08	---	0.89
	May 1	6	0.61	0.65	0.63	0.10	0.10	---	1.07
	May 9	8	0.62	---	---	0.08	0.08	---	1.20
	May 16	7	1.53	---	---	0.22	0.22	---	1.88
	May 23	7	---	1.14	---	0.16	0.16	---	1.21
	May 25	2	0.32	0.30	0.31	0.16	0.16	---	0.25
	May 31	6	1.01	---	---	0.17	0.17	---	1.17

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches				Atmosphere evaporation, in milliliters		ET/ Evapora- tion Ep, : in inches	Pan evapora- tion Ep, : in inches
			Tank 1	Tank 2	Tank 3	Mean	Black	White		
CENTRAL VALLEY (continued)										
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)										
Pasture (continued)	1960									
Alturas Dorris	June 7	7	----	----	----	1.96d	500f	360f	140f	1.96
Ranch 5/b/	June 14	7	1.41	----	----	0.20	437	308	129	1.73
(continued)	June 21	7	----	----	----	1.96d	459	343	116	1.96
	June 22	1	----	----	----	0.26e	e/	e/	e/	e/
	June 28	6	1.36	----	----	0.23	459	319	140	1.98
	July 5	7	1.94	1.92	----	1.93	466	331	135	1.82
	July 12	7	2.21	2.39	----	2.30	536	410	126	2.11
	July 19	7	2.42	2.32	----	2.37	524	385	139	1.95
	July 26	7	----	2.24	----	0.32	592	469	123	2.18
	Aug. 1	6	----	1.49	----	0.20	347	262	85	1.39
	Aug. 3	2	----	0.62	----	0.31	e/	e/	e/	0.55
	Aug. 8	5	----	1.47	----	0.29	495	370	125	1.32
	Aug. 16	8	----	2.46	----	0.31	540	430	110	2.27
	Aug. 22	6	----	1.97	----	0.33	546	433	113	1.82
	Aug. 29	7	----	1.88	----	0.27	387	282	105	1.55
	Aug. 31	2	0.59	----	----	0.30	133	106	27	0.51
	Sept. 5	5	1.25	----	----	0.25	358	285	73	1.31
	Sept. 12	7	1.44	----	----	0.21	371	272	99	1.32
	Sept. 19	7	1.37	----	----	0.20	406	300	106	1.44
	Sept. 26	7	1.37	1.21	----	1.29	371	272	99	1.24
	Sept. 30	4	0.63	0.69	----	0.66	188	144	44	0.60
	Oct. 3	3	0.49	0.45	----	0.47	159	116	43	0.50
	Oct. 10	7	0.86	0.94	----	0.90	13	---	---	0.94
	Oct. 16	6	0.64	----	----	0.11	---	---	---	0.61
										1.05

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches				Atmosphere, evaporation, in milliliters		ET / Evapora- tion Ep, : in inches :	Fan
			Tank 1	Tank 2	Tank 3	Mean : daily	Black	White		
SACRAMENTO RIVER BASIN MOUNTAIN VALLEYS (continued)										
CENTRAL VALLEY (continued)										
Pasture (continued)	1960									
Alturas Dorris Ranch 2/5/ (continued)	Oct. 22	6	0.64	0.66	---	0.65	0.11	---	---	0.86
	Oct. 28	6	0.60	0.72	---	0.66	0.11	---	---	0.89
	Oct. 31	3	0.21	0.26	---	0.24	0.08	---	---	0.92
	Nov. 7	7	---	---	---	0.55 ^d	0.08	---	---	---
	Nov. 14	7	---	---	---	0.13 ^d	0.02	---	---	---
	Nov. 21	7	---	---	---	0.03 ^d	0.00	---	---	---
	Dec. 1	10	0.23	0.11	---	0.17	0.02	---	---	0.45
	Dec. 9	8	0.12	0.46	---	0.29	0.04	---	---	1.81
	Dec. 14	5	0.02	0.18	---	0.10	0.02	---	---	1.11
	Dec. 20	6	0.13	0.21	---	0.17	0.03	---	---	1.42
	Dec. 28	8	0.11	0.19	---	0.15	0.02	---	---	0.65
	Dec. 31	3	0.07	0.01	---	0.04	0.01	---	---	0.20
SACRAMENTO RIVER BASIN VALLEY FLOOR										
Eyeggrass	1958									
Davis Campbell b/i/	Sept. 6	4	---	---	---	---	---	---	---	---
	Sept. 10	4	1.22	0.80	1.04	1.02	0.26	---	74 ^b / ₁₀₀ 0.0138	0.80
	Sept. 13	3	---	---	---	---	---	---	56 ^b / ₁₀₀ 0.0102	---
	Sept. 18	5	1.10	0.98	0.98	1.02	0.20	---	100 ^b / ₁₀₀ 1.62	0.63
	Sept. 25	7	1.70	1.03	1.03	1.25	0.18	---	134 ^b / ₁₀₀ 0.0093	0.57
	Sept. 29	4	---	---	---	---	---	---	76 ^b / ₁₀₀ ---	---
	Oct. 6	7	1.96	1.53	1.47	1.65	0.24	---	95 ^b / ₁₀₀ 0.0174	0.91
	Oct. 15	9	2.02	1.96	1.59	1.86	0.21	---	109 ^b / ₁₀₀ 0.0171	0.89
	Oct. 22	7	1.13	1.13	1.19	1.15	0.16	---	65 ^b / ₁₀₀ 0.0177	0.81
	Oct. 29	7	0.80	0.86	0.98	0.88	0.13	---	51 ^b / ₁₀₀ 0.0172	0.96

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches					Atmosphere		ET/ET-w	Pan evaporation, in inches	
			Tank 1	Tank 2	Tank 3	Mean daily	Black	White				
CENTRAL VALLEY (continued)												
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)												
Ryegrass (continued) 1958												
Davis Campbell												
b/l/ (continued)												
Nov. 4	6		0.99	0.93	1.12	1.01	0.11	231	189	424/	0.64	
Nov. 13	9		0.48	0.60	0.48	0.52	0.10	377	316	614/	1.26	
Nov. 18	5		0.43	0.31	0.37	0.37	0.05	---	---	---	0.50	
Nov. 26	8		0.55	0.49	0.31	0.45	0.08	---	---	---	0.46	
Dec. 2	6							---	---	---	---	
Dec. 15	13		0.06	0.37	0.18	0.20	0.02	---	---	---	---	
Dec. 31	16		0.60	0.53	0.60	0.58	0.04	---	---	---	---	
1959												
Dec. 31	-							---	---	---	---	
Feb. 2	33		1.22	1.40	1.65	1.42	0.04	---	---	---	2.03	
Feb. 19	17		1.53	2.08	1.71	1.77	0.10	---	---	---	1.46	
Feb. 27	8		0.42	0.60	0.48	0.50	0.06	---	---	---	0.72	
Mar. 17	18		2.20	2.45	3.43	2.69	0.15	---	---	---	4.31	
Apr. 1	15		1.47	1.84	1.96	1.76	0.13	---	---	---	2.26	
Apr. 16	15		2.69	3.24	1.59	2.51	0.17	---	---	---	4.26	
Apr. 20	4		---	---	---	0.54/	0.14	---	---	---	0.93	
Apr. 23	3		---	---	---	0.35/	0.12	---	---	---	0.61	
Apr. 30	7		---	---	---	0.93/	0.13	---	---	---	1.59	
May 7	7		1.41	1.10	0.92	1.14	0.16	---	---	---	1.99	
May 14	7		1.84	1.65	1.71	1.73	0.25	---	---	---	2.35	
May 21	7		---	---	---	1.56/	0.22	---	---	---	2.56	
May 28	7		0.98	1.10	1.10	1.06	0.15	---	---	---	1.91	

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

-118-

TABLE A-7 (continued)

EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches				Atmosphere evaporation, in milliliters				ET/ET _w	Pan evaporation Ep, in inches	
			Tank 1	Tank 2	Tank 3	Mean	Black	White	ET _w				
CENTRAL VALLEY (continued)													
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)													
Ryegrass (continued) 1959													
Davis Campbell	Nov. 12	9	1.38 ¹ / ₂	1.43	1.37	1.40	0.16	752	634	113 ¹ / ₂	0.0143	2.67	0.52
b/1/ (continued)	Nov. 20	8	0.84 ¹ / ₂	0.67	----	0.67	0.07	472	360	112 ¹ / ₂	0.0060	1.23	0.54
	Nov. 20	8	0.49	0.55	----	0.52	0.06	----	----	----	----	0.58	0.90
	Dec. 5	15	0.83	0.92	1.04	0.93	0.06	----	----	----	----	2.38	0.41
	Dec. 15	10	0.28	0.31	0.34	0.31	0.31	----	----	----	----	1.04	0.30
	Dec. 22	7	0.24	0.12	0.21	0.19	0.03	----	----	----	----	0.31	0.61
	Dec. 31	9	0.48	0.39	0.27	0.38	0.04	----	----	----	----	0.33	1.15
1960													
	Dec. 31	-	----	----	----	----	----	----	----	----	----	----	----
	Jan. 12	12	0.22	0.34	0.34	0.30	0.02	----	----	----	----	0.73	0.41
	Jan. 19	7	0.21	0.28	0.09	0.19	0.03	----	----	----	----	0.37	0.51
	Jan. 26	7	0.57	0.11	0.24	0.31	0.04	----	----	----	----	0.28	1.11
	Jan. 30	4	0.03	0.00	0.09	0.04	0.01	----	----	----	----	0.10	0.40
	Feb. 8	9	----	----	m/	0.16 ¹ / ₂	0.02	----	----	----	----	0.60	0.27
	Feb. 15	7	----	----	m/	0.53 ¹ / ₂	0.08	----	----	----	----	0.68	0.78
	Feb. 26	11	0.80	0.86	0.86	0.84	0.08	----	----	----	----	1.60	0.52
	Mar. 8	11	0.54	0.79	0.54	0.62	0.06	----	----	----	----	0.75	0.83
	Mar. 18	10	0.94	1.18	1.47	1.20	0.12	----	----	----	----	1.65	0.73
	Mar. 31	13	1.81	1.32	1.45	1.53	0.12	----	----	----	----	1.81	0.85
	Apr. 12	12	1.92	2.04	1.98	1.98	0.16	----	----	----	----	2.43	0.81
	Apr. 18	6	1.04	1.22	1.16	1.14	0.19	----	----	----	----	1.62	0.70
	Apr. 29	11	1.68	1.72	1.78	1.73	0.16	----	----	----	----	1.60	1.08
								446	308	138	0.0125		

TABLE A-7 (continued)
 EVAPOTRANSPIROMETER MEASUREMENTS AND RELATED DATA
 FOR HIGH WATER TABLE PASTURE AND IRRIGATED RYEGRASS

Area, crop, and station name	Period ending	Number of days	Evapotranspiration (ET) for period of measurement, in inches				Atmosphere evaporation, in milliliters				ET/ET ₀	Pan evaporation, in inches	ET/ET ₀
			Tank 1	Tank 2	Tank 3	Mean	Mean	Black	White	ET ₀			
CENTRAL VALLEY (continued)													
SACRAMENTO RIVER BASIN VALLEY FLOOR (continued)													
Ryegrass (continued) Davis Campbell h/i/ (continued)	1960 May 10	11	2.35	2.19	2.23	2.26	0.21	604	421	183	0.0123	2.50	0.90
	May 26	16	3.69	3.71	3.62	3.67	0.23	1169	899	270	0.0136	4.95	0.74
	June 1	6	1.65	1.47	1.59	1.57	0.26	509	392	117	0.0135	1.75	0.91
	June 9	8	1.42	1.29	1.30	1.34	0.17	788	634	154	0.0087	3.60	0.37
	June 13	4	0.95	0.89	1.29	1.04	0.26	335	250	85	0.0122	1.34	0.78
	June 22	9	1.50	1.29	1.12	1.30	0.14	1047	864	183	0.0071	3.95	0.33
	July 1	9	2.05	2.40	2.11	2.19	0.24	717	532	185	0.0117	3.13	0.70
	July 6	5	1.29	1.22	1.35	1.29	0.26	423	318	105	0.0123	1.78	0.82
	July 8	2	0.61	0.55	0.61	0.59	0.30	163	123	40	0.0148	0.72	0.72
	July 12	4	0.74	0.80	0.61	0.72	0.18	338	250	88	0.0082	1.46	0.49
	July 19	7	1.64	1.64	1.67	1.65	0.24	633	476	157	0.0105	2.48	0.67
LAHONTAN													
LASSEN-ALPINE MOUNTAIN VALLEYS													
Pasture Coleville 2W 2/h/	1957 May 27	-	----	----	----	----	----	----	----	----	----	----	----
	June 3	7	1.34	----	----	----	0.19	----	----	----	----	1.38	0.97
	June 6	3	0.73	----	----	----	0.24	----	----	----	----	0.79	0.92
	June 10	4	0.95	----	----	----	0.24	----	----	----	----	0.75	1.27
	June 17	7	1.34	----	----	----	0.19	502	365	137	0.0098	1.63	0.82
	June 24	7	1.93	----	----	----	0.28	569	415	154	0.0125	2.29	0.84
	June 30	6	1.96	----	----	----	0.33	542	399	143	0.0137	1.85	1.06
	July 8	8	2.27	----	----	----	0.28	639	491	148	0.0153	2.22	1.02
	July 16	8	2.50	----	----	----	0.31	693	527	166	0.0151	2.46	1.02
	July 29	13	3.58	----	----	----	0.28	995	760	235	0.0152	3.70	0.97
	Aug. 1	3	0.77	----	----	----	0.26	277	225	52	0.0148	0.95	0.81

AGROCLIMATIC STATIONS

ACTIVE - 1960

ACTIVE - PRE 1960

1. Macdoel F. S.
2. Montague 3NE
3. Yreka 1NE
4. Davis Creek 4WNW
5. Grenada 6E
6. Fort Jones R. S.
7. Gazelle 1NNE
8. Gazelle 3NNW
9. Big Sage Reservoir
10. Cedarville Chevron
11. Cedarville 2E
12. Cedarville 1E
13. Alturas Park Avenue
14. Alturas Dorris Ranch
15. Canby Ohm
16. Canby R. S.
17. Canby 11SW
18. Callahan Towne Ranch
19. Mt. Shasta City W. B.
20. Lukely Williams Ranch
21. Lukely 4N
22. Adin Harper
23. Adin R. S.
24. West Valley Reservoir
25. Lookout 1S
26. Lookout Hunt
27. Bieber 4E
28. Bieber S. C. S.
29. McArthur 2E
30. Pittville 1S
31. Glenburn DWR
32. Fall River Mills 4NW
33. Fall River Mills R. S.
34. Fall River Mills Intake
35. Madeline 3SW
36. Termo
37. Hat Creek 3N
38. Hat Creek 3SE
39. Bella Vista 4NE
40. Eagle Lake Stone Ranch
41. Hayfork R. S.
42. Redding R. S.
43. Redding Stayer
44. Redding 6SE
45. Redding A. P.
46. Anderson 2E
47. Anderson 3E
48. Anderson 4E
49. Leavitt Lake
50. Standish 4NW
51. Standish 1NW
52. Red Bluff 3E
53. Red Bluff Cone Ranch
54. Corning 3NW
55. Corning 3NE
56. Corning Jobe
57. Vina Beck
58. Quincy R. S.
59. Newville
60. Loyaltown 5W
61. Loyaltown 7N
62. Hamilton City
63. Mills Orchard
64. Oroville Agric. Comm.
65. Richvale 1E
66. Sacramento Refuge
67. Palermo 3SW
68. Pennington 3NW
69. Live Oak 3SE
70. Loma Rica
71. Browns Valley 3NE
72. Penn Valley
73. Tahoe
74. Yuba City
75. Yuba City 9W
76. Arbuckle 1S
77. Lincoln Vineyard
78. Auburn Mt. Vernon
79. Gold Hill Doty Flat
80. Rocklin Igarashu
81. Woodfords
82. Davis Campbell #1
83. Davis Campbell #2
84. Coleville 2W
85. Elk Grove 4NW
86. Bridgeport DWR
87. Thornton 2S
88. Twitchell Island
89. Lodi 3SW
90. Lodi 3S
91. Stockton 8S
92. Stockton 9S
93. El Solyo Ranch
94. Vernalis 3SE
95. Ceres 3E
96. Atwater 1N
97. Newman 1SE
98. Merced 5SE
99. Berenda 2N
100. Los Banos 3S
101. Los Banos Equipment Yard
102. Los Banos 8SE
103. Kerman 2ESE
104. Fresno Kearney Pa. k
105. Mendota Murietta Ranch
106. Panoche Junction
107. Kingsburg 5S #1
108. Kingsburg 5S #2
109. Shafter 2NW
110. Arvin Frick
111. Arvin Jewett #1
112. Arvin Jewett #2



STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
VEGETATIVE WATER USE STUDIES
INTERIM REPORT

GENERAL LOCATION
OF
AGROCLIMATIC STATIONS
1954-1960

SCALE OF MILES

20 0 20 40 60



4

ACTIVE - PRE 1960

- | | | |
|-----------------------------|----------------------------|-----------------------------|
| 26. Macdoel F S. | 39. Bella Vista 4NE | 76. Arbuckle 15 |
| 27. Montague NE | 40. Eagle Lake Stone Ranch | 77. Lincoln Vineyard |
| 28. Yreka NE | 41. Hayfork R S. | 78. Auburn Mt. Vernon |
| 29. Redding Creek 4WNW | 42. Redding R. S. | 79. Cold Hill Dry Flat |
| 30. Grenada 6E | 43. Redding Stayer | 80. Rockin Igarsah |
| 31. Fort Jones NE | 44. Redding 6SE | 81. Woodfords |
| 32. Hazelle 4NE | 45. Redding A. P. | 82. Davis Campbell #1 |
| 33. Gaselle 3NNW | 46. Anderson SE | 83. Davis Campbell #2 |
| 34. Bug Sage Reservoir | 47. Anderson SE | 84. Coleville 2W |
| 35. Cedarville Chevron | 48. Anderson 4E | 85. Elk Grove 4NW |
| 36. Cedarville 4W | 49. Leitch Lake | 86. Bridgeport DWR |
| 37. Cedarville IE | 50. Standish 4NW | 87. Thornton 25 |
| 38. Alturas Park Avenue | 51. Standish 3NW | 88. Twichell Island |
| 39. Alturas Derran Ranch | 52. Red Bluff IE | 89. Loch 3SW |
| 40. Canby 6W | 53. Red Bluff Comm Ranch | 90. Loch 3S |
| 41. Canby R S. | 54. Corning 3NW | 91. Stockton 8S |
| 42. Canby 15SW | 55. Corning 3NE | 92. Stockton 9S |
| 43. Callahan Stone Ranch | 56. Corning Jobe | 93. El Soljo Ranch |
| 44. Mr. Szara 4W NW | 57. Corning 3SE | 94. Central 3SE |
| 45. Lakely Williams Ranch | 58. Quincy R. S. | 95. Ceres 3SE |
| 46. Lakely 4N | 59. Newellie | 96. Arwater 1N |
| 47. Adan Harper | 60. Loyation 5W | 97. Newman 1SE |
| 48. Adm R S. | 61. Loyation 7N | 98. Merced 5SE |
| 49. West Valley Reservoir | 62. Hamilton City | 99. Berenda 2N |
| 50. Lookout 1S | 63. Mills Orchard | 100. Los Banos 3S |
| 51. Lookout 4E | 64. Broville Agric Comm. | 101. Los Banos Empment Yard |
| 52. Bieler 4E | 65. Richvale IE | 102. Los Banos 5SE |
| 53. Bieler S C 5 | 66. Sacramento Refuge | 103. Kerman 2ESE |
| 54. McArthur 2E | 67. Paleremo 3SW | 104. Fresno Kearney Pa. k |
| 55. McArthur 3E | 68. Beunington 3NW | 105. Mendota-Morrista Ranch |
| 56. Glenhurst DWR | 69. Love Oak 3SE | 106. Pancho Junction |
| 57. Fall River Mills 4NW | 70. Loma Rica | 107. Kingsburg 5S #1 |
| 58. Fall River Mills R S. | 71. Browns Valley 3NE | 108. Kingsburg 5S #2 |
| 59. Fall River Mills Intane | 72. Browns Valley | 109. Kingsburg 5E |
| 60. Madeline 3SE | 73. Tahoe | 110. Arvin Frick |
| 61. Termo | 74. Yuba City | 111. Arvin Jewett #1 |
| 62. Hat Creek 3SE | 75. Yuba City 9W | 112. Arvin Jewett #2 |

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
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DIVISION OF RESOURCES PLANNING
VEGETATIVE WATER USE STUDIES
INTERIM REPORT

GENERAL LOCATION OF AGROCLIMATIC STATIONS 1954-1960

SCALE OF MILES





EVAPOTRANSPIRATION STATIONS

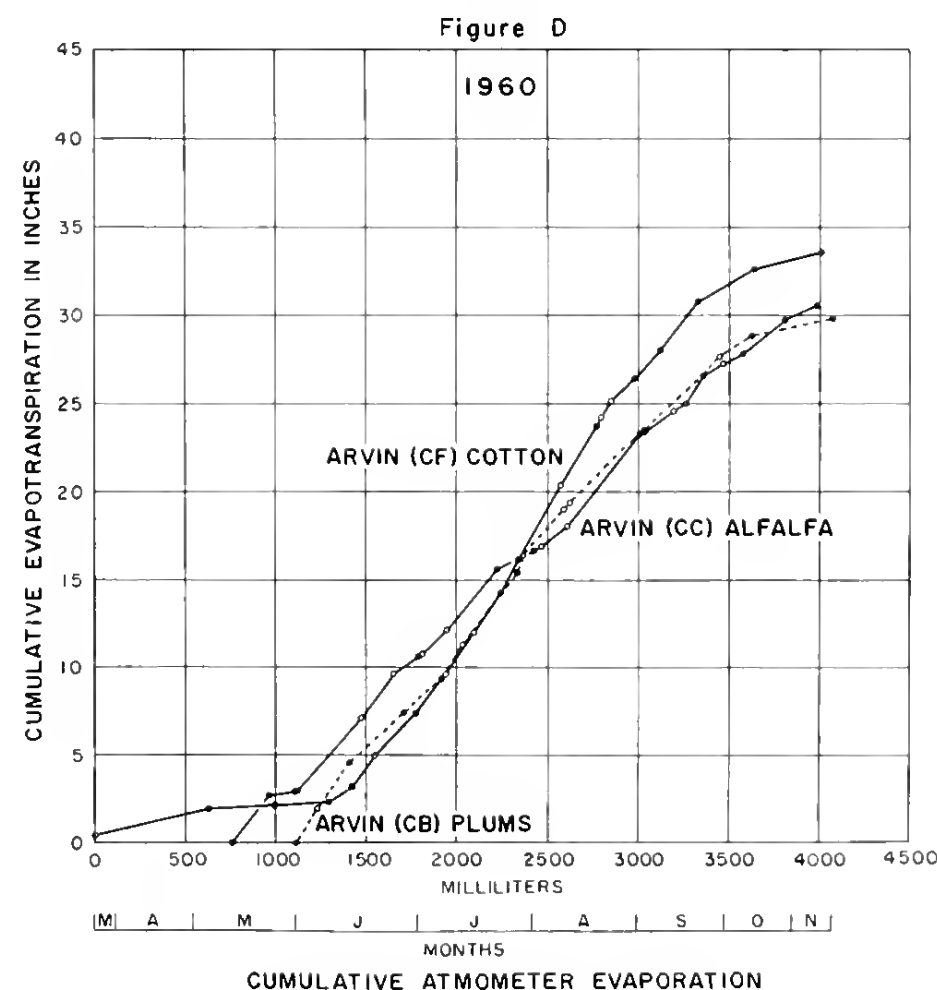
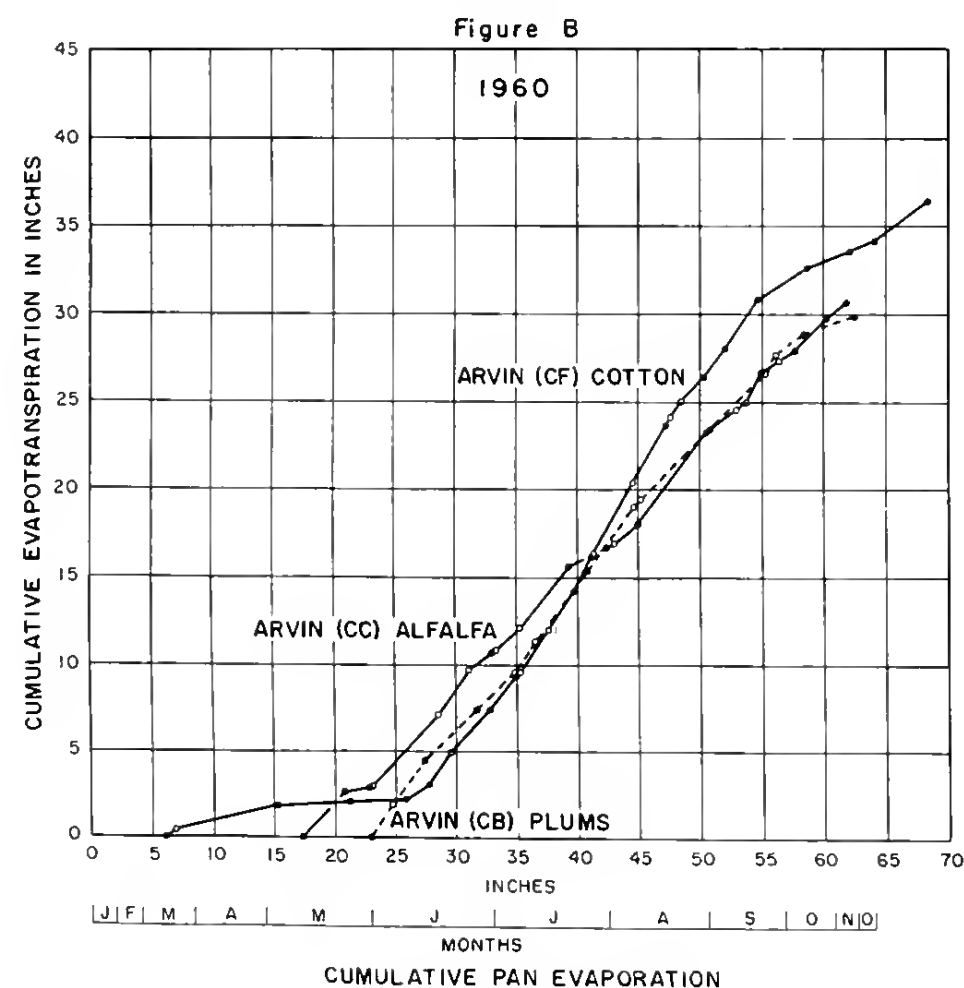
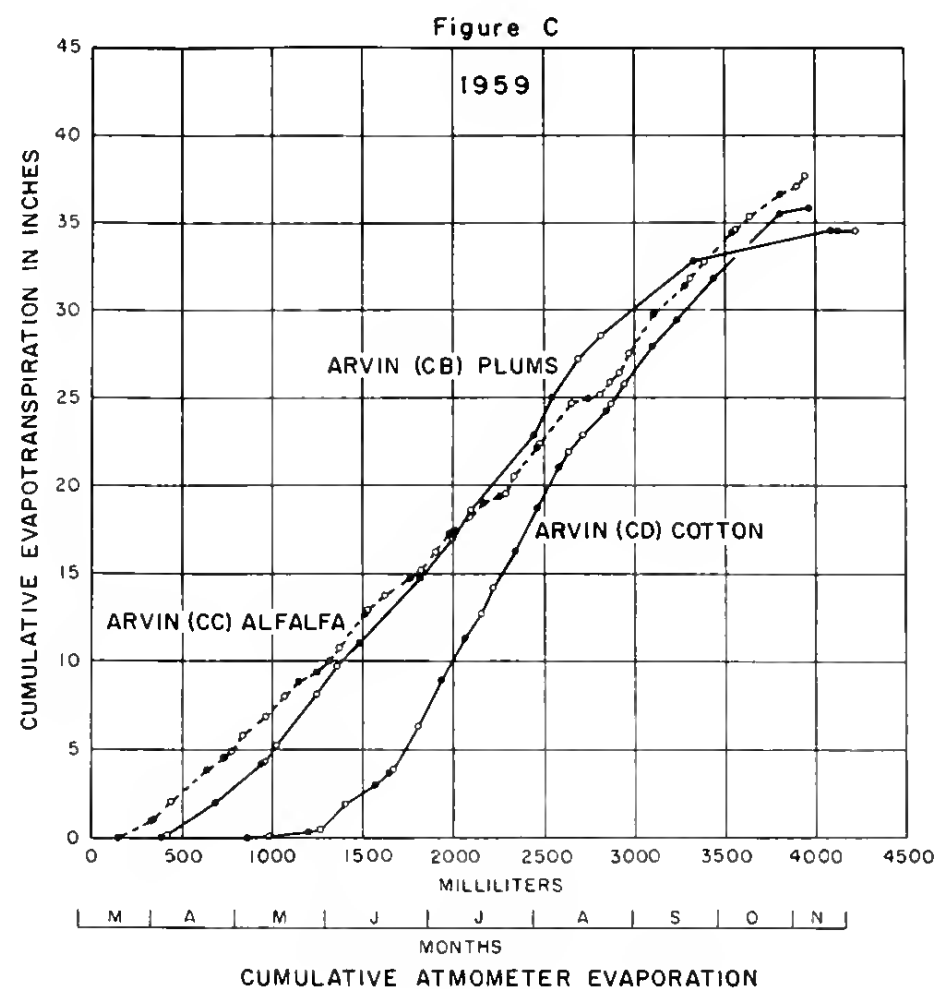
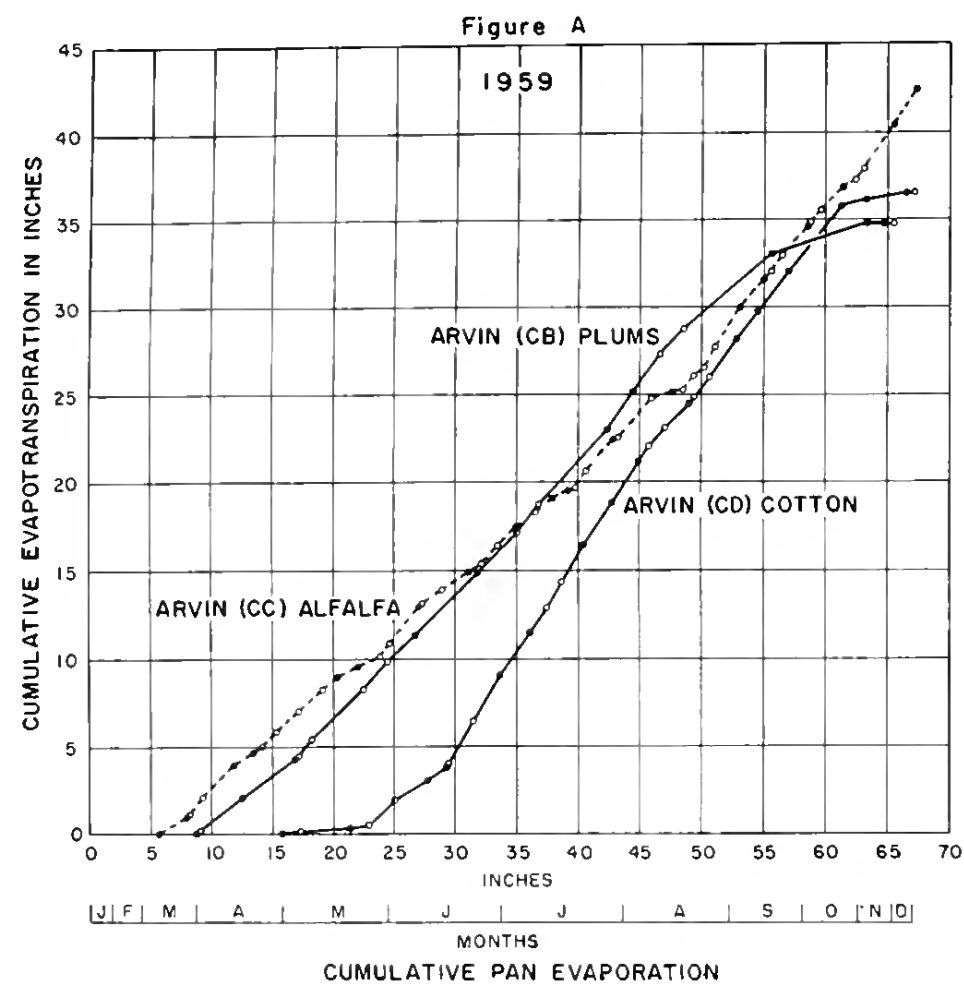
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 EVAPOTRANSPIROMETER - ACTIVE PRE 1960
 NEUTRON PROBE - ACTIVE IN 1960
 NEUTRON PROBE - ACTIVE PRE 1960
 GRAVIMETRIC - ACTIVE PRE 1960

1. Gazelle Dougherty #1
2. Gazelle Dougherty #2
3. Gazelle Dougherty #3
4. Canby Bushey
5. Alturas Dorris Ranch
6. Beeber JE
7. Beeber Leonard
8. Pittville (AA)
9. McArthur (AB)
10. McArthur (AC)
11. McArthur Albaugh #1
12. McArthur Albaugh #2
13. Pittville (B)
14. Hat Creek Kern
15. Hat Creek Opdyke
16. Redding (SE)
17. Anderson 2N
18. Anderson 3E
19. Anderson Trisdale
20. Leavitt Lake
21. Mills Orchard
22. Coleville 2W
23. Davis Campbell
24. Arvin (CE)
25. Arvin (CC)
26. Arvin (CB)
27. Arvin (CF)
28. Arvin (CD)
29. Arvin Jewett
30. Arvin Jewett #2
31. Arvin Jewett #3

STATE OF CALIFORNIA
 THE RESOURCES AGENCY OF CALIFORNIA
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 VEGETATIVE WATER USE STUDIES
 INTERIM REPORT

GENERAL LOCATION OF EVAPOTRANSPIRATION STATIONS 1955-1960

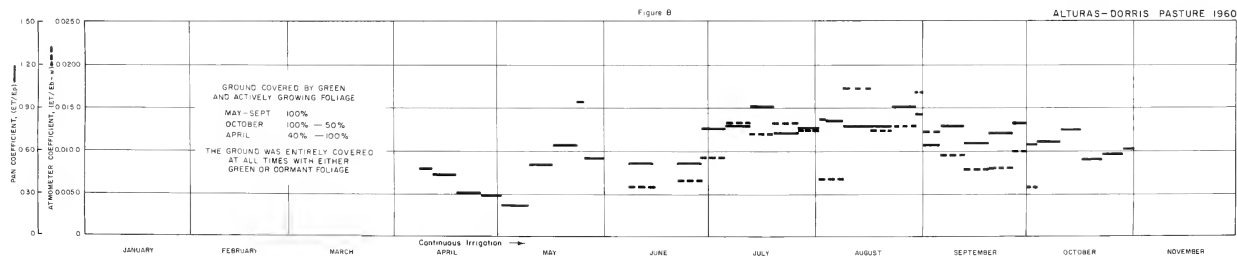
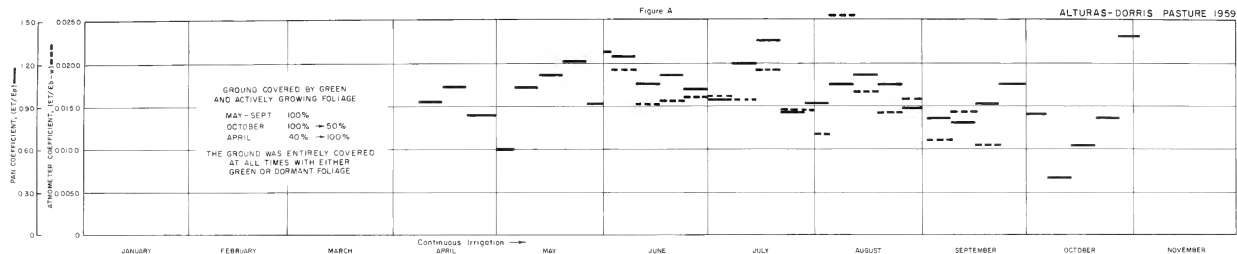
SCALE OF MILES
 0 20 40 60



NOTE: SLOPE DIFFERENCES ARE DUE TO PLANT
CONDITIONS, SOIL MOISTURE AVAILABILITY,
AND OTHER FACTORS
CODE: • EVAPOTRANSPIRATION MEASURED
◊ EVAPOTRANSPIRATION ESTIMATED

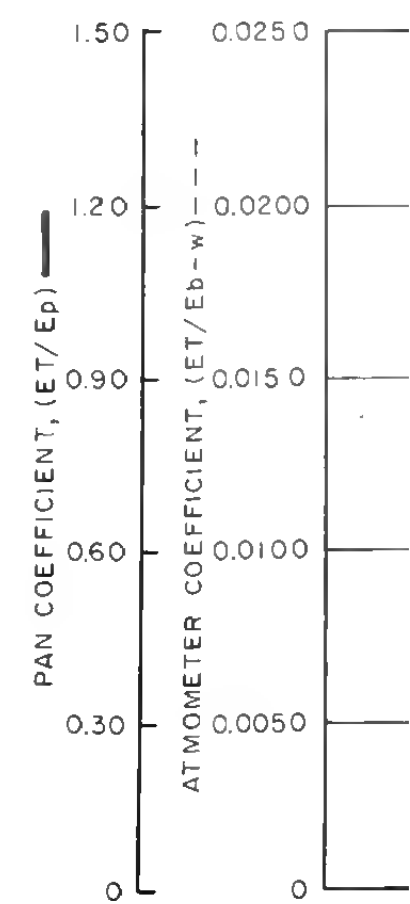
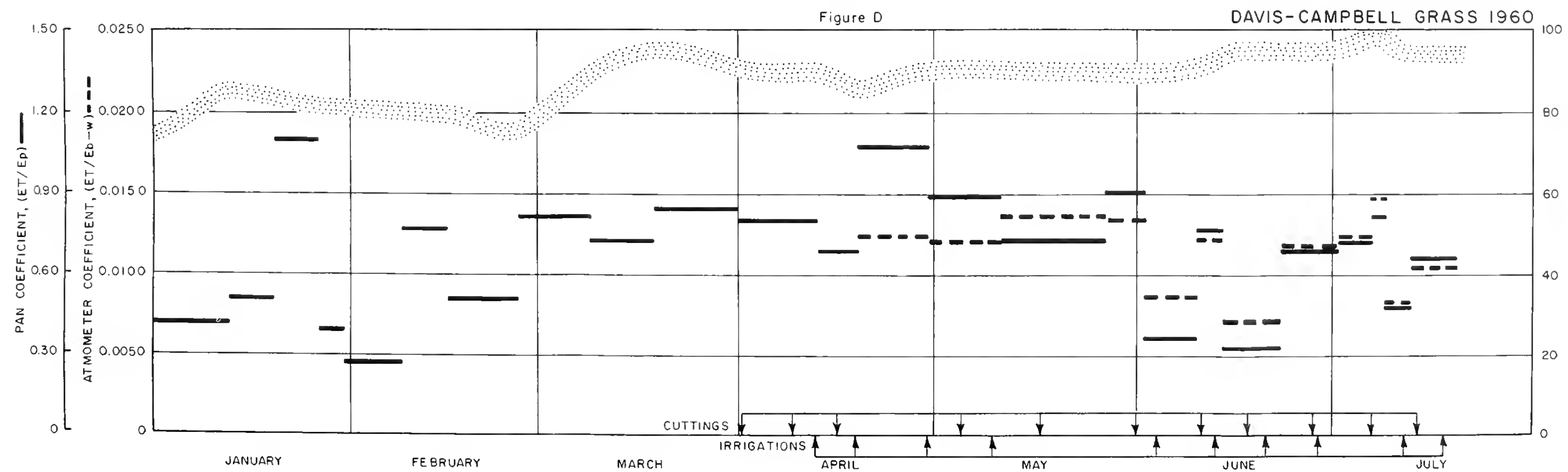
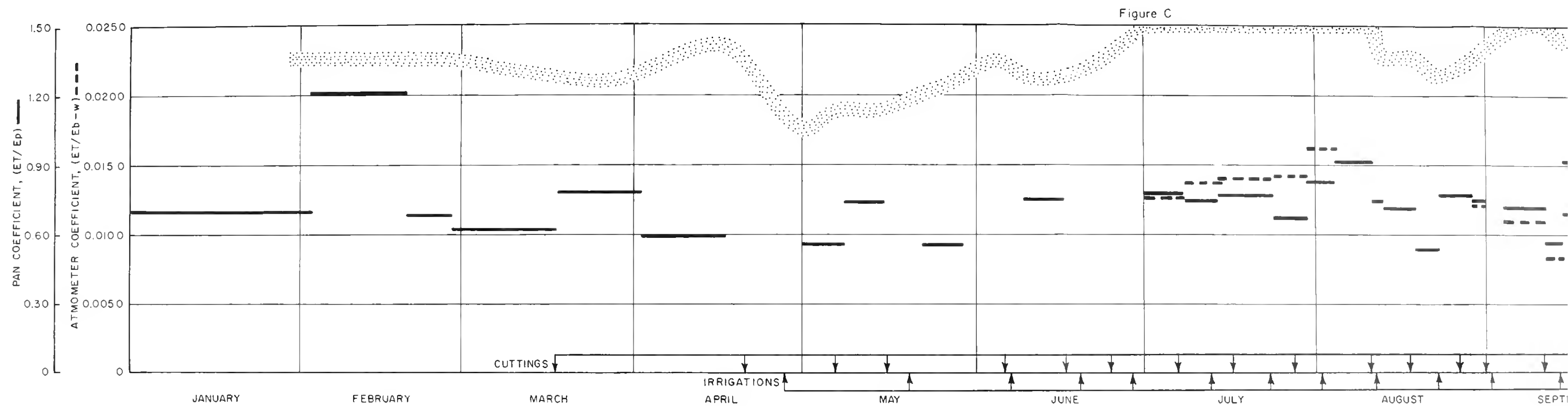
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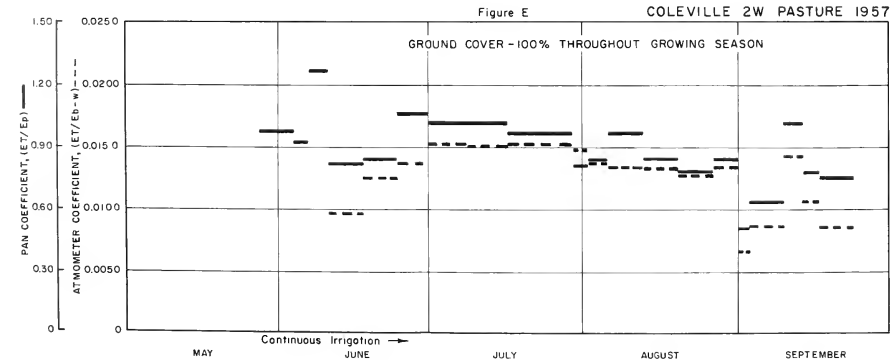
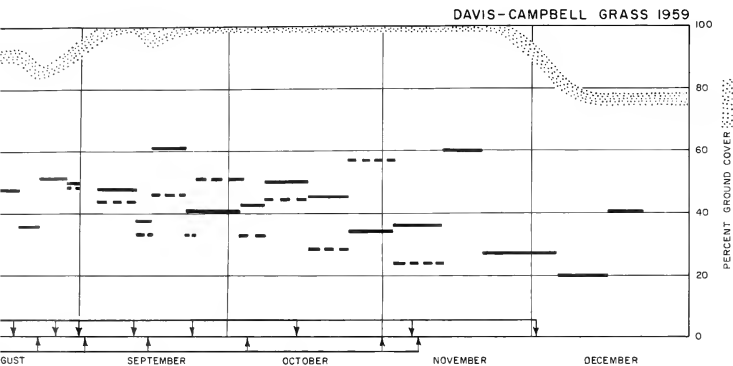
COMPARISON OF EVAPOTRANSPIRATION CURVES
OF
DIFFERENT CROPS GROWN
AT THE
SAME LOCATION ON THE SAME SOIL SERIES
OCTOBER 1962



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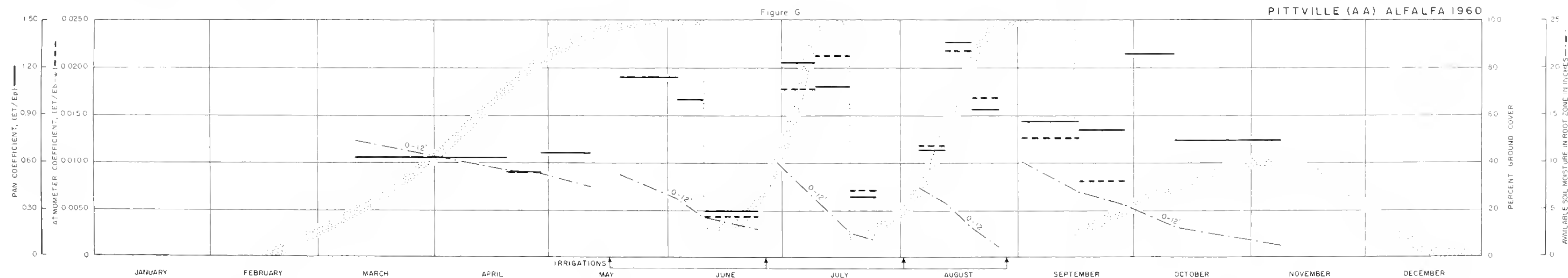
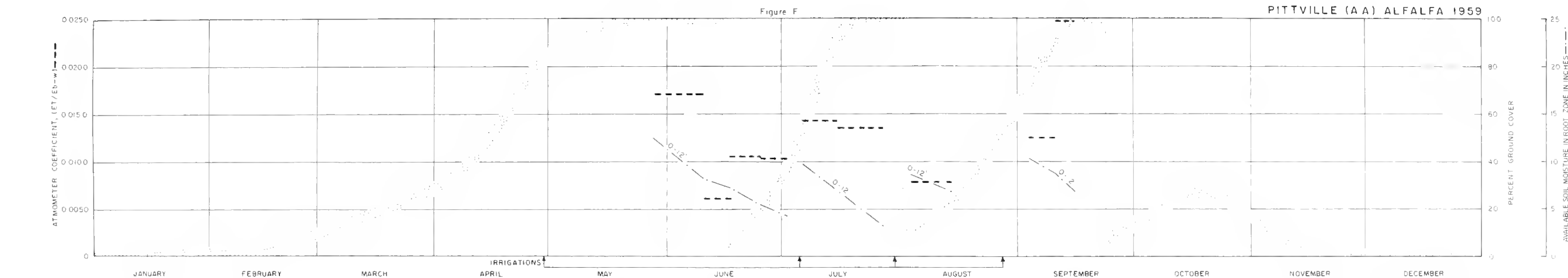
VARIATION OF PAN AND ATMOMETER COEFFICIENTS
FOR
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WITH RESPECT TO
CROP GROUND COVER, AVAILABLE SOIL MOISTURE
AND OTHER PLANT CONDITIONS
OCTOBER 1962





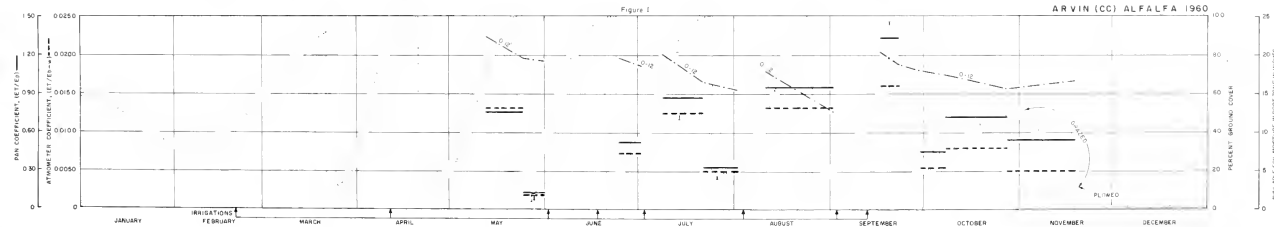
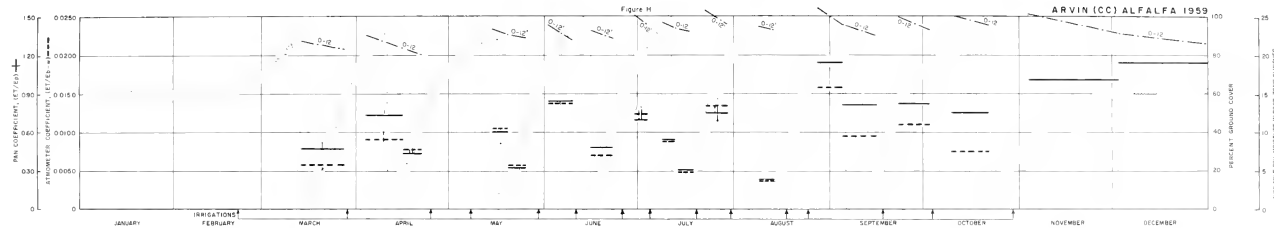
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VARIATION OF PAN AND ATMOMETER COEFFICIENTS
FOR
INDIVIDUAL PERIODS OF MEASUREMENTS
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AND OTHER PLANT CONDITIONS
OCTOBER 1962



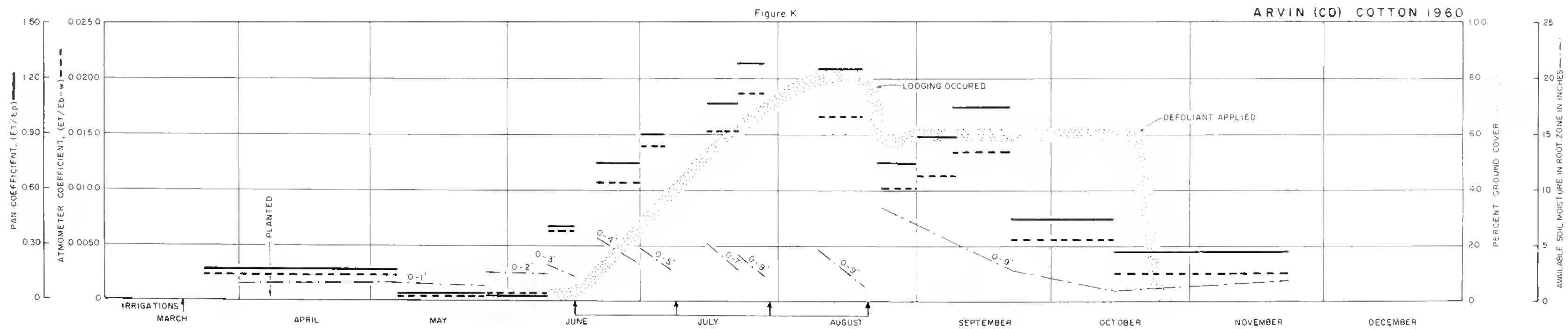
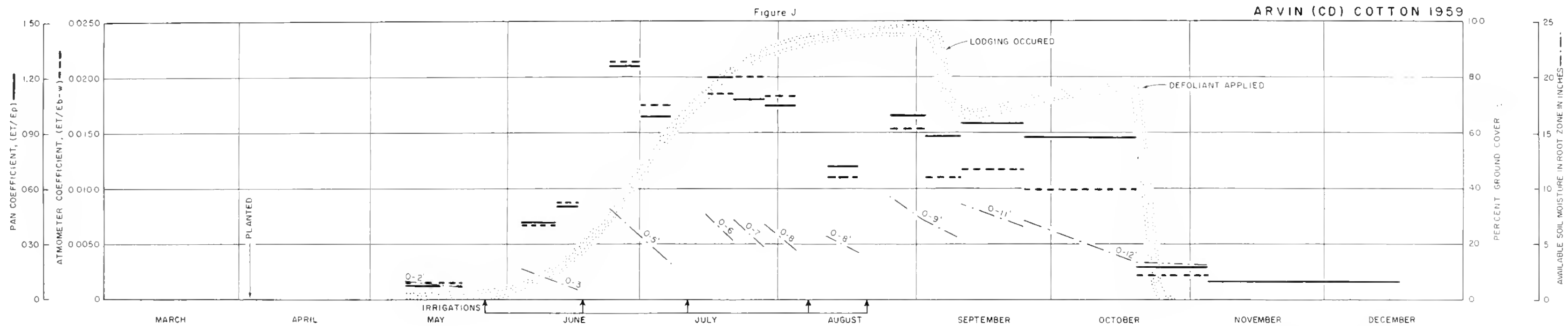
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INDIVIDUAL PERIODS OF MEASUREMENTS
WITH RESPECT TO
CROP GROUND COVER, AVAILABLE SOIL MOISTURE
AND OTHER PLANT CONDITIONS
OCTOBER 1962



FOR RESOURCES PLANNING IN CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
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 INTERIM REPORT

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 OCTOBER 1962



STATE OF CALIFORNIA
 THE RESOURCES AGENCY OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 DIVISION OF RESOURCES PLANNING
 VEGETATIVE WATER USE STUDIES
 INTERIM REPORT

VARIATION OF PAN AND ATMOMETER COEFFICIENTS
 FOR
 INDIVIDUAL PERIODS OF MEASUREMENTS
 WITH RESPECT TO
 CROP GROUND COVER, AVAILABLE SOIL MOISTURE
 AND OTHER PLANT CONDITIONS
 OCTOBER 1962

Figure A

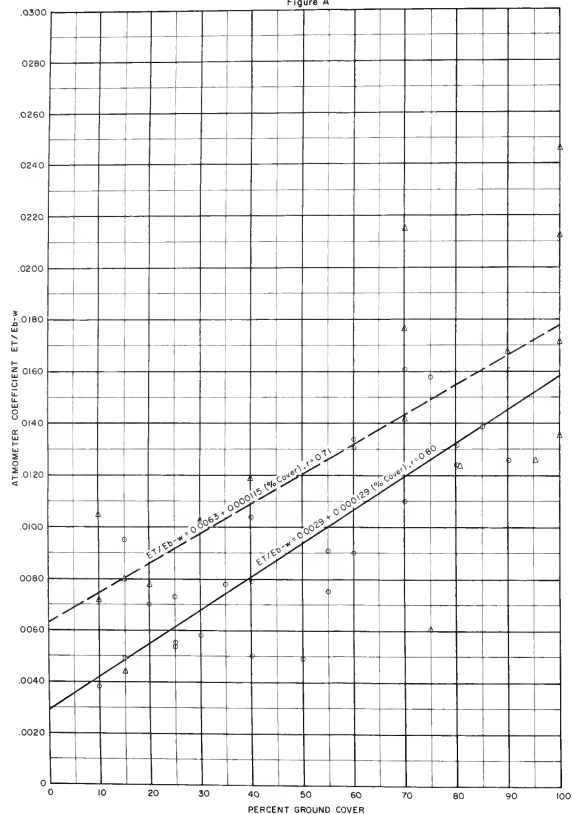
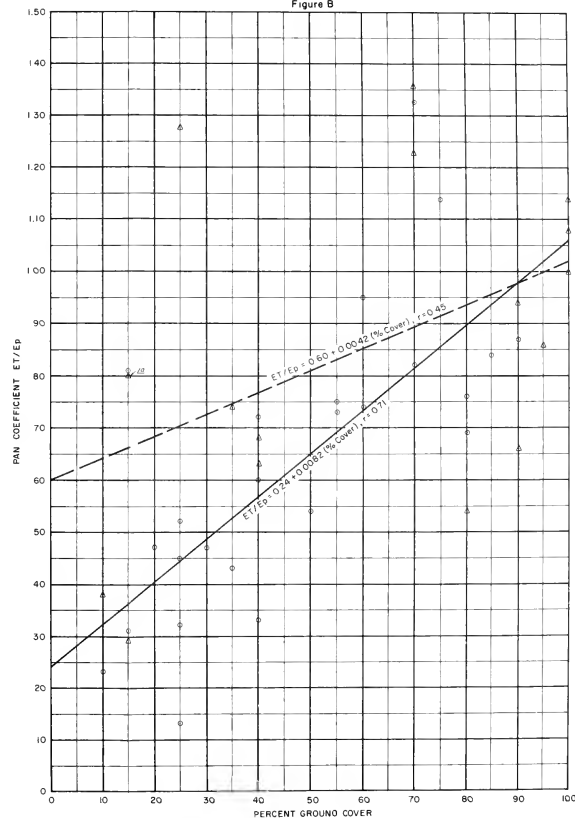


Figure B



LEGEND

- ARVIN (CC) ALFALFA
 — PITTVILLE (BA) ALFALFA

△: SOMEWHAT HIGHER THAN WOULD BE EXPECTED DUE TO EVAPORATION OF gpm

NOTE: PERCENT GROUND COVER DATA TAKEN FROM TABULATION BASED ON CURVES DRAWN USING DATA IN APPENDIX TABLE OF NEUTRIN DATA

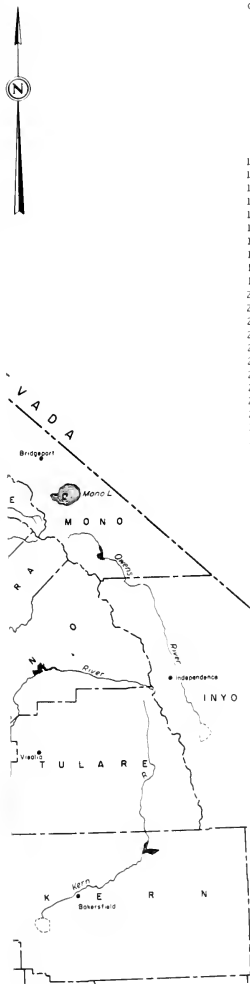
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 VEGETATIVE WATER USE STUDIES
 INTERIM REPORT
 RELATIONSHIP BETWEEN
 PAN AND ATMOMETER COEFFICIENTS
 FOR ALFALFA AND GROUND COVER
 DATA ARE FOR 1959 AND 1960

EVAPOTRANSPIRATION STATIONS

+

EVAPOTRANSPIROMETER - ACTIVE IN 1960
EVAPOTRANSPIROMETER - ACTIVE PRE 1960
NEUTRON PROBE - ACTIVE IN 1960
NEUTRON PROBE - ACTIVE PRE 1960
GRAVIMETRIC - ACTIVE PRE 1960

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DEPARTMENT OF WATER RESOURCES
DIVISION OF RESOURCES PLANNING
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GENERAL LOCATION
OF
EVAPOTRANSPIRATION STATIONS
1955-1960

SCALE OF MILES
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